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of the

American Railway Engineering and Maintenance-of-Way Association

Vol. II NOVEMBER, 1900 No. I

CONTENTS:

LOCOMOTIVE TONNAGE RATING—SOUTHERN PACIFIC COMPANY—PACIFIC SYSTEM

Also an Appendix
Containing a Synopsis of Minutes of the Board Meeting,
List of New Members, List of Standing Committees, Mileage Table, Etc.

Published under the Direction of the
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LIST OF OFFICERS.

1900.

President.

J. F WALLACE, Illinois Central Railroad, Chicago. Ill.

First Vice-President—One Year.

P. A. PETERSON, Canadian Pacific Railway, Montreal, Can.

Second Vice-President—Two Years.

HUNTER McDONALD, Nashville, Chattanooga & St. Louis Railway, Nashville, Tenn.

Secretary.

L. C. FRITCH, Baltimore & Ohio Southwestern Railroad, Washington, Ind. (Office, 1562 Monadnock, Chicago, Ill.)

Treasurer.

W. S. DAWLEY, Chicago & Eastern Illinois Railroad, Chicago, Ill.

Directors.

For Three Years.

A. Torrey, Michigan Central Railroad, Detroit, Mich.
Thos. Rodd, Pennsylvania Lines West of Pittsburg, Pittsburg, Pa.

For Two Years.

D. J. Whittemore, Chicago, Milwaukee & St. Paul, Chicago, Ill.
F. H. McGuigan, Grand Trunk Railway, Montreal, Can.

For One Year.

W. K. McFarlin, Delaware, Lackawanna & Western, Hoboken, N. J.
J. Kruttschnitt, Southern Pacific Company, San Francisco, Cal.

625.06
AMR
no.1-20

INTRODUCTION

By JOHN D. ISAACS

Assistant Engineer Maintenance-of-Way, Southern Pacific Company.

IN the spring of 1899 Mr. Julius Kruttschnitt, General Manager of the Southern Pacific Company, appointed a committee for the purpose of introducing a uniform and consistent system of locomotive tonnage rating on all divisions of this Company.

After much careful consideration. collection of experimental data and theoretical investigations, the labors of this committee took the form of a report. written, in the main, by the late Mr. W. G. Curtis.

Mr. Curtis intended to somewhat amplify and to rearrange this report in order to adapt it for publication as a paper for presentation to the American Railway Engineering and Maintenance-of-Way Association. Owing, however, to his failing health, Mr. Curtis requested the writer to carry out this intention, with the results embodied in the following article.

The system here outlined went into full operation upon all of the main lines of the Southern Pacific Company July 1, 1900, with gratifying results, and is now working smoothly and satisfactorily to all parties interested.

At the request of Mr. Curtis, made a few days before his death, thanks are expressed to the following gentlemen for their assistance to him in this work: Mr. J. H. Wallace. Mr. John D. Isaacs. Mr. A. D'Heur, Mr. B. A. Worthington and Mr. R. L. Donald.

San Francisco, Cal., October 18, 1900.

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LOCOMOTIVE TONNAGE RATING[*]

SOUTHERN PACIFIC COMPANY—PACIFIC SYSTEM

J. KRUTTSCHNITT
Fourth Vice-President and General Manager

RATING COMMITTEE:

PACIFIC SYSTEM	W. G. Curtis,	Engineer M. of Way, Chairman
	H. J. Small,	Superintendent Motive Power
	F. W. Mahl,	Mechanical Engineer
ATLANTIC SYSTEM	J. T. Mahl,	Engineer M. of Way, Chairman
	J. J. Ryan,	Superintendent Motive Power
	F. W. Mahl,	Mechanical Engineer

Relation of speed and load:

To determine the relation between train speed, load and engine power in a theoretical way, apart from its application to any actual locomotive or track profile, the following data are required:

1. A formula for train resistance as a function of speed.
2. An equation connecting train speed and piston speed.
3. A curve or equation giving the mean effective pressure of the steam in the cylinders at different velocities.
4. A unit of tractive power.
5. An equation stating the relation between tractive power and train speed.
6. A tabulation of the loads capable of being hauled per unit of power at varying speeds on different grades, and based on the units and formulæ adopted.

The units and formulæ used in the development of the attached Table I are here noted:

I. *Train Resistance:* The curve as developed by A. M. Wellington, and to be found plotted on page 518 of his "Economic Theory of Railroad Location."

---

[*] Written discussions by members and others are desired.

II. An equation connecting train speed and piston speed.

$$S=\frac{X\ 56\ L}{D}$$

S=piston speed in feet per minute.
X=miles per hour (train speed).
D=diameter of driver in inches.
L=length of piston stroke in inches.

This formula is needed to transform the curve of mean effective pressure as plotted for piston speed of feet per minute into engine speed of any given locomotive.

III. The *Mean Effective Pressure* curves employed are those of the Motive Power Department, drawings P. S. M. 1023 and P. S. M. 1171.

IV. The *Unit of Traction* adopted is that cylinder capacity capable of giving a tractive effort at the rail of 1,000 pounds at a speed of ten miles per hour.

The curve adopted (P. S. M. 1023) for mean effective pressure of single expansion engines shows the average steam pressure in the cylinders, for all piston speeds below approximately 250 feet per minute, as a constant percentage of the boiler pressure. A piston speed of 265 feet per minute, for an engine with 26-inch stroke and 55-inch diameter drivers corresponds to a speed of 10 miles per hour.

Since the mean effective pressure is assumed constant below a piston speed of about 250 feet per minute, and also that train resistance according to the curve employed does not change appreciably until such low speeds occur, that sand may be used to equalize the traction, it is permissible to assume, as a general rule, that the traction is constant below a train speed of ten miles an hour.

In the use of this unit of traction, one source of error is present at low freight train speeds. It is based on cylinder power, and at low speeds the cylinders may be able to furnish more tractive power than the friction between the drivers and the rail can transmit to the drawbar. It is assumed, however, that it is safe to base the unit on traction, if at ten miles per hour train speed it does not exceed 25% of the weight on driving wheels.

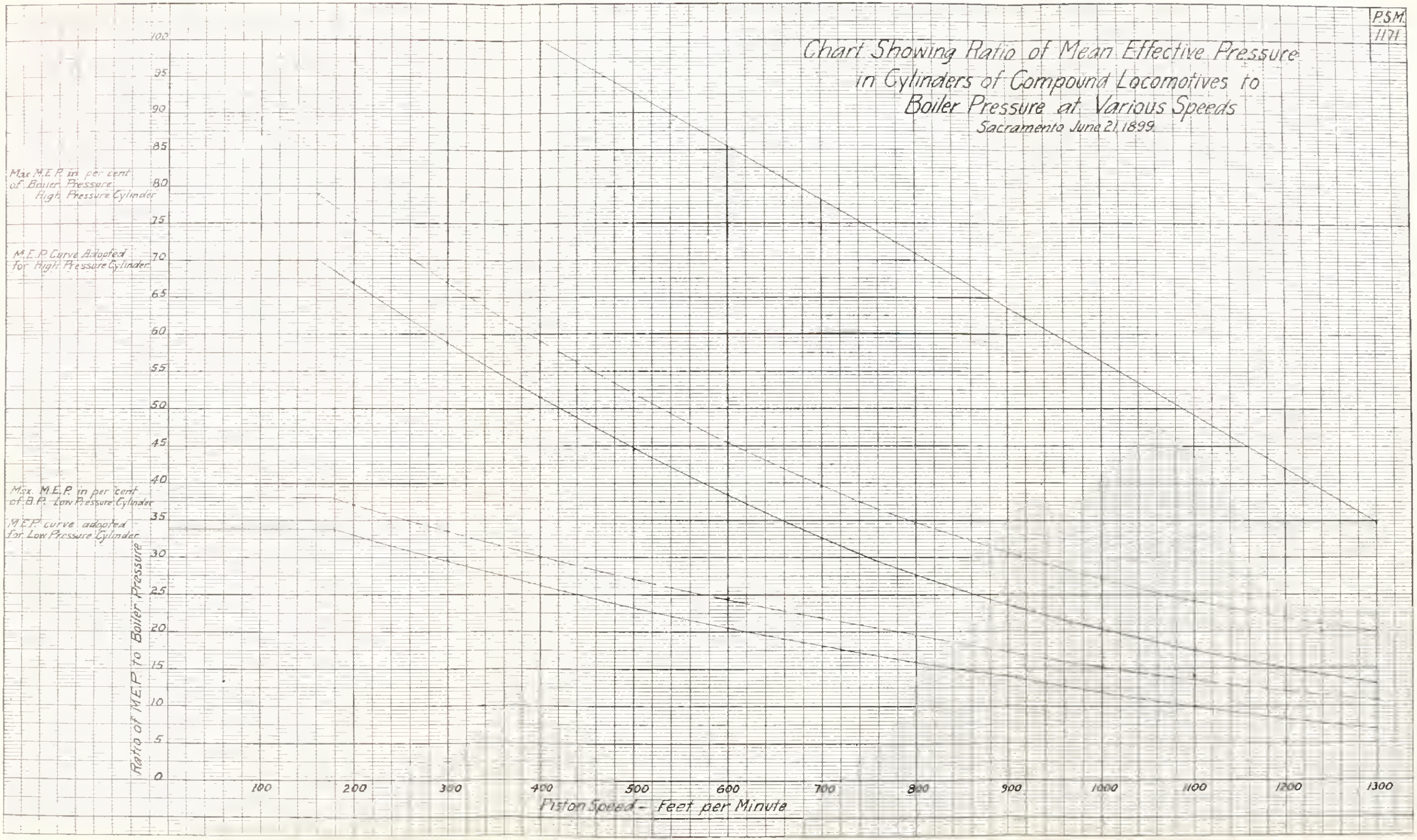

Chart Showing Ratio of Mean Effective Pressure in Cylinders of Compound Locomotives to Boiler Pressure at Various Speeds

Sacramento June 21, 1899.

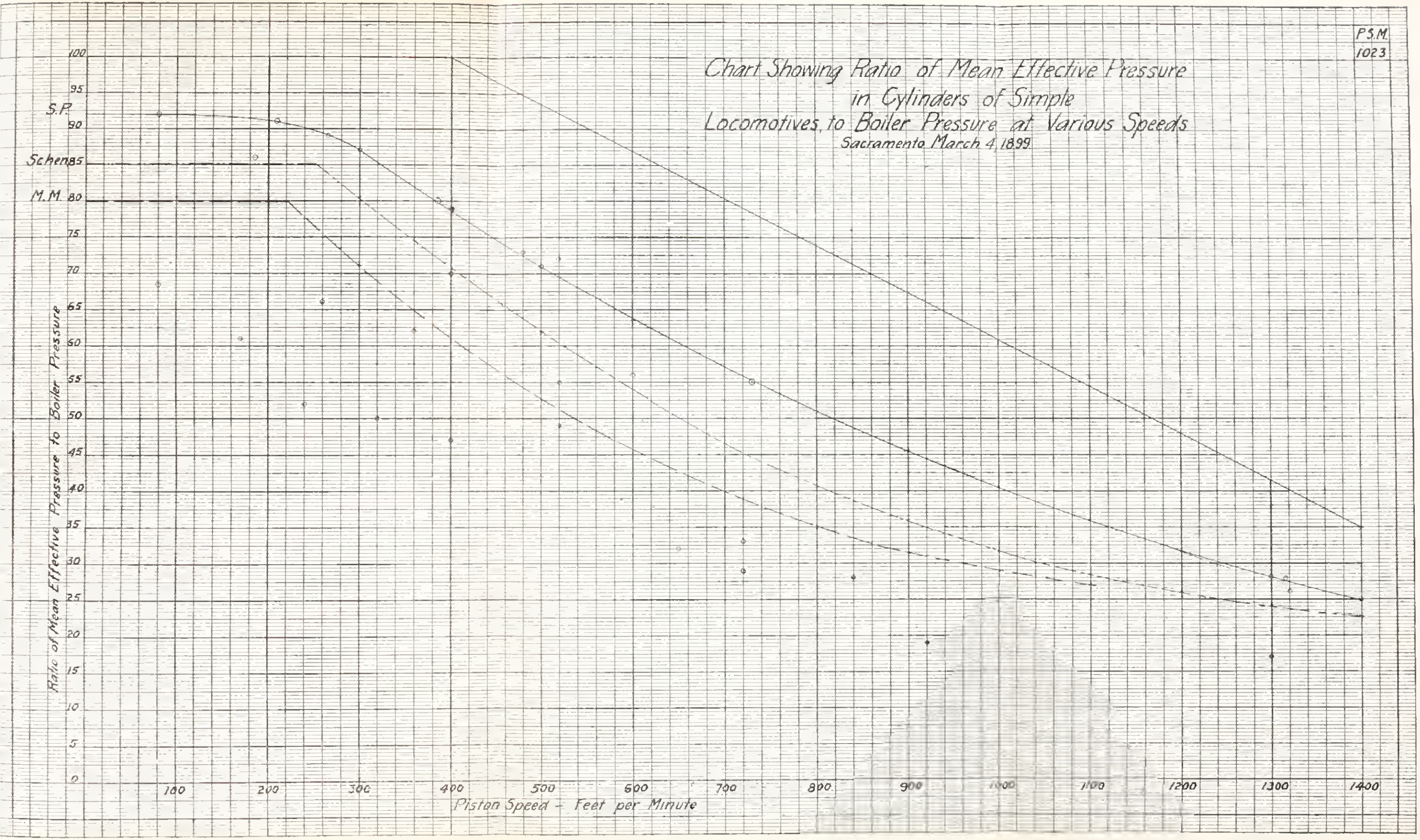

Chart Showing Ratio of Mean Effective Pressure in Cylinders of Simple Locomotives to Boiler Pressure at Various Speeds

Sacramento March 4, 1899.

V. *Tractive Power or Traction:* Based on cylinder power $= \frac{d^{2}{}^{*}\ L\ p}{D}$ when

d=diameter of piston in inches.
D=diameter of drivers.
L=length of stroke.
p=mean effective pressure.

VI. The curve of mean effective pressure can be thrown into the parabolic form of $y^2 = 2\ mx + c$, but it appears simpler to break it up into portions which may be treated as straight lines of the form $y = ax + b$, where

y=percentage of mean effective to boiler pressure.
x=miles per hour train speed.
b=constant.

The piston speed in feet per minute is changed into train miles per hour for an engine of 26-inch stroke and drivers of 55-inch diameter by the use of the formulæ on page 6 and the equations become:

1. Between rest and 10 miles per hour, $y = 0.82$
2. “ 9 m.p.h. “ 23 “ “ “ $y = -2x + 100$
3. “ 23 “ “ 38 “ “ “ $y = -1.56x + 89$
4. “ 38 “ “ 46 “ “ “ $y = -1.25x + 78.5$

It is next necessary to transform these equations to give the relation between the fall in traction and the increase in speed. The final form of the equation for fall in traction becomes:

5. From rest to 10 miles per hour, 1,000 lbs.=unit
6. “ 10 m.p.h. “ 23 “ “ “ $y = -25x + 1250$
7. “ 23 “ “ 38 “ “ “ $y = -19.8x + 1130$
8. “ 38 “ “ 46 “ “ “ $y = -15.9x + 958$

Where y = traction in pounds, x = speed in miles per hour. These equations show that the fall in traction or cylinder capacity is as follows:

10 miles per hour	1,000 lbs.
20 “ “ “	750 “
30 “ “ “	535 “
40 “ “ “	347 “

---

* More accurately $(d^2 - \frac{d_1^2}{2})$ in which d_1=diameter of piston rod.

All the above being for an engine having a piston with 26-inch stroke and drivers of 55-inch diameter.

VII. From the foregoing data it is possible to calculate a table giving the load which can be hauled, per unit of power, at any desired speed on any given grade. For convenience in application, all loads are in "M's," or units of 1,000 pounds. Having calculated the traction at any given speed from the formulæ noted under paragraph V, and numbered 5, 6, 7 and 8, it is evident that the load per unit of power which can be hauled is that found by dividing the traction at the desired speed by the total resistance per M for speed and grade. Thus, in column 3, Table I, attached, the traction available at 25 miles per hour is 635 pounds; that is, for every unit of power supplied (1,000 pounds of traction at a speed of ten miles per hour), only 0.635 units (or 635 pounds) are available to haul at 25 miles per hour, due to fall in mean effective pressure. The train resistance at a speed of 25 miles per hour is given in column 4, Table I, as 4.4 pounds per M. This resistance, divided into the available traction of 635 pounds, gives 144 M's as the load which can be hauled per unit of power on a level track. Assuming that 25 miles per hour is to be made on a + 0.5% grade, the total resistance will be 4.4 pounds train resistance per M and 5 pounds per M grade resistance. This resistance of 9.4, divided into the traction power of 635 pounds, gives 67.5 M's as the load which can be hauled, per unit of power, at the given speed on the given grade.

It is to be noted that the resistance will be the same whether the constant load is being hauled up an actually existing + 0.5% grade at a constant speed, or whether the speed is being accelerated to such a point that the increased resistance and fall in mean effective pressure consume an amount of power equal to the resistance of a + 0.5% grade. In each case the 5 pounds per M would be used. In the first case, in elevating every M a distance of 0.5 feet and in the second case in raising the velocity head a proportional amount.

Columns 32 to 39 inclusive of Table I are based on the fact that, for trains on descending grades, the gravity force is negative (exerted as a pull). For each column the "grade resistance" at the head of it is deducted from the train resistance,

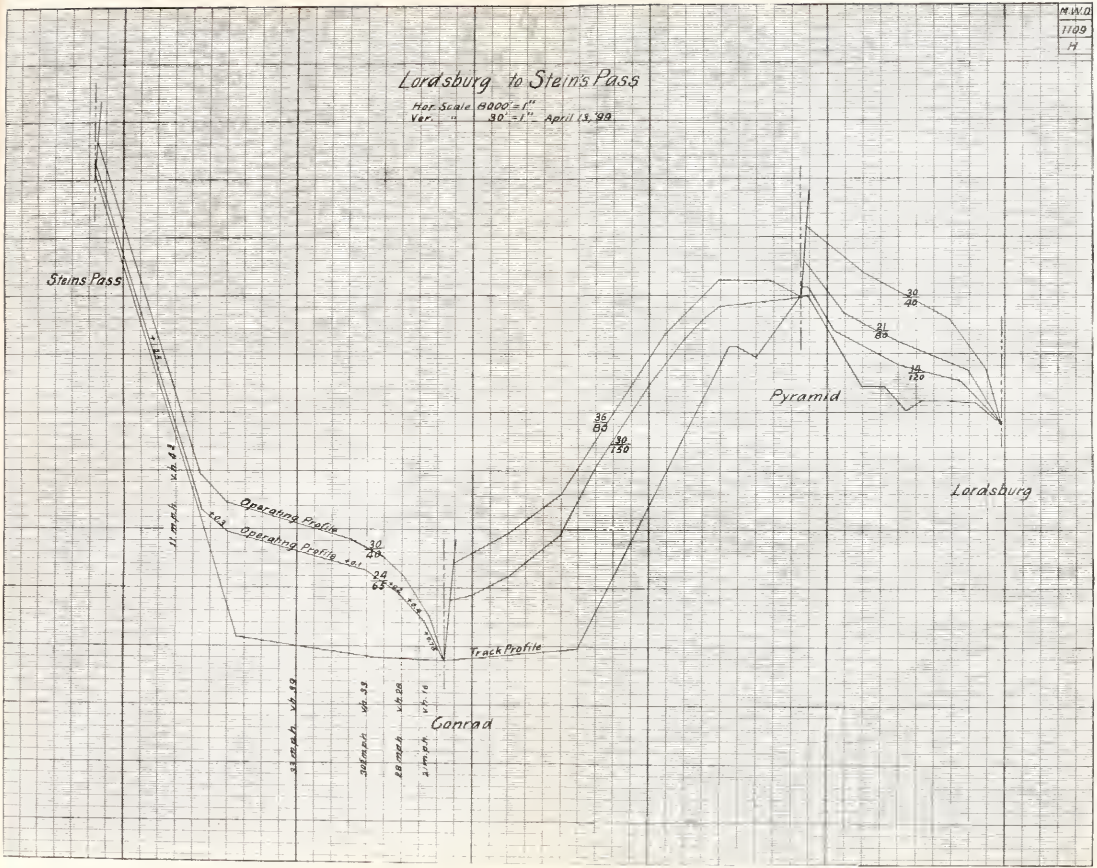
M.W.D.
1109
H
Lordsburg to Stein's Pass
Hor. Scale 8000' = 1"
Ver. " 30' = 1" April 13, '99
Steins Pass
+2.6
11 m.p.h. v.h. 4.4
+0.3
Operating Profile
Operating Profile
+0.1
30/40
24/65
+0.2
+0.4
+0.75
Track Profile
33 m.p.h. v.h. 3.9
30.5 m.p.h. v.h. 3.3
28 m.p.h. v.h. 2.8
21 m.p.h. v.h. 1.6
Conrad
36/80
30/150
Pyramid
30/40
21/80
14/120
Lordsburg

FIG. 1.

in column 4, and the remainder or net resistance used as a divisor for traction in column 3 for each given speed.

Examples:

$\frac{1{,}000}{2.4-1}=715=$ M's haulable per unit of power on a -0.1% grade at ten miles per hour.

$\frac{347}{8-7.5}=694=$ M's haulable per unit of power on -0.75% grade at forty miles per hour.

The application of this table to an actual profile requires the conditions of operating to be considered. In working up the tabulation of speed and load, as shown in Table II, the conditions to be stated are:

a. The maximum speed at any point in miles per hour.

b. The minimum speed on ruling grades and elsewhere in miles per hour, except during acceleration from or coming to rest. It is not advisable to rate for reaching any grade summit with a less velocity than ten miles per hour, as a head wind or any slight increase in train resistance not allowed for would be sufficient to destroy the momentum and to stall the train.

A speed of ten miles per hour being measured by the low velocity head of 3.5 feet.

c. The train to start from rest at every station.

In column 2, Table I, the velocity heads are given opposite each speed. This velocity head corresponds to the momentum of the train at each speed and is taken from Table 118 of A. M. Wellington's "Theory of Railroad Location," which is based on the formula,

$$\text{Velocity head} = \frac{V^2 \text{ in feet per second}}{2\,g}$$

This is the well-known form of equation for the velocity of a body falling freely through a given height and accelerated by gravity alone. To the quantity given by the formula for each velocity has been added a percentage due to the rotative energy of the wheels; the rotative energy being a function of the radius of gyration of the wheels. This column of velocity heads corresponds to the "vertical distance through which momentum alone can lift a train at any given velocity against the force of gravity," and conversely measures the work which has already been done in accelerating the train to that velocity. If the velocity heads at each point on the track be plotted, and lines be drawn joining these velocity heads, these lines will measure the grades whose resistances equal the power consumed or acquired by the change in speed or elevation.

From the foregoing it will be seen that it is possible to construct a profile which may be called the "Operating Profile," and which will show the equivalent grades and velocity heads at different points along any portion of the road. If a section of track be taken, its profile plotted with allowance for curvature, as explained in footnote,* and any load per unit of tractive power assumed, it is possible to select such a combination of equivalent grades from Table I that at all times the engine shall be working to its full capacity and making its maximum speed consistent with the conditions imposed and already noted on page 9. A sample of such operating profile between Lordsburg and Stein's Pass is attached (Fig. 1). Its object is to determine the maximum load which can be hauled between any two points at various average speeds in miles per hour. In this way, to form a basis for speed rating as well as tonnage rating, Table II, M. W. D. 1108 B, gives the result obtained from the operating profile between Lordsburg and Tucson. The following describes the method pursued in plotting the portion between Conrad and Stein's Pass.

It is evident from inspection that the load is controlled by the long grade up to Stein's Pass and that it is impossible to get up sufficient momentum at the foot of the grade to reach the summit on any lighter equivalent grade. It is found that the controlling grade is one of 1.25%, and on reference to Table I,

---

* NOTE.—The gradient per cent assumed as offering a resistance equal to that of one degree of curvature is 0.04 feet for curves up to 7 degrees, and 0.05 feet for curves between 7 degrees and 10 degrees. This means that a 10 degree curve is considered to offer as much resistance as a grade of +0.5%. In plotting the track profile, whenever curves occur on level line or gradients which are uncompensated for curvature, the grade measuring the curve resistance should be plotted in its correct location, as it is possible for a heavy train moving at a low speed to be stalled on an uncompensated curve. Where compensation for curvature has been made, it is sufficient to take the total degrees of curvature on the gradient, multiply it by its equivalent grade, either 0.04 feet or 0.05 feet, and thus obtain the height in feet which measures the resistance offered by the curvature. The height thus found is to be added to the difference in elevation of any two points for an ascending movement and subtracted for a descending movement. This corrects the profile for the resistance offered by curvature and makes the profile ready for the application of the operating profile as described hereafter. On figure 2 is shown the change in gradient due to curvature between Stein's Pass and Vanarman.

RATING OF ENGINES. TABLE II.

June, 1900.

M. W. D.
1108
B

Speed Conditions.—To start from rest at all stations. Minimum speed on ruling grades, 10 miles per hour. Maximum speed at any point, 35 miles per hour.

Tabulation of M's of train load (including engine, tender, etc.) per M of power at given average speed between stations noted.

LORDSBURG TO TUCSON—WESTBOUND.

Distance bet. Stations, Miles.		Miles per hour,	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	I. R.
	FROM	TO																									
4.40	Lordsburg	Pyramid								100	95	90	85	80	75	70	65	61	56	52	48	44	40				100
7.50	Pyramid	Conrad																				150	120	103	90		F
7.60	Conrad	Stein's Pass															61	56	52	48	44	40					61
4.75	Conrad	Sub-station									150	142	135	127	120	112	104	96	88	80	72	64	56	48	40		150
2.85	Sub-station	Stein's Pass			60	58	56	54	52	49	46	44	42	40	38	36	34	32	30								61
7.00	Stein's Pass	Vanarman																								150	182
7.70	Vanarman	San Simon				Brakes required to hold velocity below 35 miles per hour.																					400
7.50	San Simon	Olga												150	143	136	129	122	115	108	100	91	82	72	61	50	250
8.20	Olga	Bowie						135	125	115	107	100	95	90	85	80	75	70	65	60	55	50	45	40			135
7.50	Bowie	Luzena							81	78	75	72	69	66	63	60	57	55	53	51	49	47	45				81
8.40	Luzena	R. R. Pass	81	77	73	69	65	62	59	56	54	52	50	48	46	44	42	40									81
7.80	R. R. Pass	Willcox																							150	132	F
5.10	Willcox	Duval												150	137	125	112	100	93	86	81	77	73	70			F
5.70	Duval	Cachise															81	74	68	62	56	50	45	40			81
5.87	Cachise	Manzoro				80	77	74	71	68	65	62	60	57	54	51	49	46	43	40							81
4.13	Manzoro	Dragoon						80	76	73	69	66	63	59	56	53	49	46	43	40							81
6.68	Dragoon	Ochoa				Brakes required to hold velocity below 35 miles per hour.																					F
6.30	Ochoa	Sybil				Brakes required to hold velocity below 35 miles per hour.																					F
3.60	Sybil	Visnaga				Brakes required to hold velocity below 35 miles per hour.																					F
4.70	Visnaga	Benson																						60	50	40	63
4.40	Benson	Chamiso	60	57	54	51	48	46	44	42	40																58
4.60	Chamiso	Mescal									60	57	54	52	50	48	46	44	42	40							61
5.08	Mescal	Kadmon				Brakes required to hold velocity below 35 miles per hour.																					416
6.00	Kadmon	Pantano				Brakes required to hold velocity below 35 miles per hour.																					416
4.08	Pantano	Irene				Brakes required to hold velocity below 35 miles per hour.																					F
5.22	Irene	Vail										100	95	90	85	80	75	70	65	60	55	50	45	40			100
4.80	Vail	Esmond				Brakes required to hold velocity below 35 miles per hour.																					F
7.90	Esmond	Wilmot				Brakes required to hold velocity below 35 miles per hour.																					F
6.70	Wilmot	Tucson				Brakes required to hold velocity below 35 miles per hour.																					F

TUCSON TO LORDSBURG—EASTBOUND.

Distance bet. Stations, Miles.	FROM	TO	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	I. R.
6.70	Tucson	Wilmot				80	77	74	71	69	65	63	60	57	55	53	50	47	45	42	40						81
7.90	Wilmot	Esmond					80	76	73	71	68	65	63	60	57	55	53	50	47	45	42	40					81
4.80	Esmond	Vail		80	78	76	73	71	68	65	63	60	57	54	51	48	44	40									81
5.22	Vail	Irene							80	76	73	70	66	63	60	56	52	49	46	43	40						81
4.08	Irene	Pantano		80	74	69	64	60	56	53	50	47	45	43	41	40											81
6.00	Pantano	Kadmon		80	75	71	68	64	60	57	54	51	48	46	44	42	40										81
5.08	Kadmon	Mescal	80	76	72	68	65	62	59	56	54	52	50	48	46	44	42	40									81
4.60	Mescal	Chamiso				Brakes required to hold velocity below 35 miles per hour.																					416
4.40	Chamiso	Benson				Brakes required to hold velocity below 35 miles per hour.																					F
4.70	Benson	Visnaga									62	57	52	48	44	40											62
3.60	Visnaga	Sybil			56	54	52	50	47	44	42	40															57
6.30	Sybil	Ochoa							61	59	57	55	53	51	49	47	45	43	41	40							61
6.68	Ochoa	Dragoon		80	76	74	71	68	65	62	59	56	53	50	47	44	42	40									81
4.13	Dragoon	Manzoro																								90	90
5.87	Manzoro	Cachise				Brakes required to hold velocity below 35 miles per hour.																					F
5.70	Cachise	Duval																		150	127	107	92	80	72	65	204
5.10	Duval	Willcox									150	146	141	136	131	126	121	115	108	100	89	80	71				157
7.80	Willcox	R. R. Pass							90	87	84	80	76	72	68	64	60	57	54	51	49	47	45				90
8.40	R. R. Pass	Luzena																								90	90
7.50	Luzena	Bowie				Brakes required to hold velocity below 35 miles per hour.																					F
8.20	Bowie	Olga																				150	136	122	108	94	F
7.50	Olga	San Simon																	150	120	92	80	68	58	49	40	180
7.70	San Simon	Vanarman										61	58	55	52	49	46	44	42	40							61
7.00	Vanarman	Stein's Pass			60	58	56	54	52	50	48	46	44	42	40												60

column 16, it is seen that the maximum load (in M's per unit of power) which can be taken up this grade is 67 M's at 10 miles per hour. Although this is the maximum load and speed per unit of power, on this grade, it is evident that a much greater load can be hauled on the light grade between Conrad and the foot of the grade. Unless it be intended to double the hill, this is impracticable, and the only other way in which the power supplied for hauling up the hill can be utilized on the light grades at the foot is by increasing the velocity and thus raising the average speed between the stations. The load plotted is 65 M's. It was found above that 67 M's could be taken, but to keep even numbers 65 M's is close enough. By following the imaginary line, which may be drawn on Table I, joining the points giving a load of 65 M's, all the speeds and equivalent grades can be picked out at which this load can be hauled. Thus, starting from rest at Conrad, Table I shows that an acceleration can be made equivalent to hauling the load up a + 0.75% grade, until a speed of approximately 21 miles per hour is obtained.

This corresponds to a velocity head of nearly 16 feet. The grade of + 0.75% is then run in until a distance of 16 feet is intercepted between the track and operating profiles. This means that every unit of power supplied on the basis of the unit adopted can accelerate 65 M's of load to a speed of 21 miles per hour, and that the force available for acceleration is that which would move the load continuously on a + 0.75% grade at a speed of 21 miles per hour. Beyond this speed the accelerating force will diminish, or, in other words, the equivalent grade becomes more nearly level as the velocity increases. The next equivalent grade or rate of acceleration beyond 21 miles per hour is taken at + 0.4% until 28 miles per hour is reached, this being the maximum obtainable with this load; thence on a + 0.2% grade until 30.5 miles per hour is reached with a velocity head of 33 feet. Following this a + 0.1% grade has been plotted and finally a + 0.3% grade, until the momentum or kinetic energy of the train is absorbed in climbing the actually existing gradient and the speed is reduced to 11 miles per hour on the controlling gradient, and on which it was found that every unit of power could haul 65 M's of load at a speed of 11 miles per hour. From these plotted velocity heads, the average speed made between Conrad and Stein's Pass is obtained. The method of reducing the average speed is as shown in Table III:

TABLE III.

DEDUCTION OF AVERAGE SPEED, CONRAD TO STEIN'S PASS.

Total distance in units of 2,000 ft.	Units where Averages Apply.	Velocity Head		Average Speed * M. P. H.	Product of Unit and Average Speed.
		Beginning.	End.		
20	5.5	4.3	4.3	11.	60.5
	1.	4.3	15.	16.5	16.5
	1.	15	33.	26.	26.
	1.	33.	43.	33.	33.
	7.	43.	33.	33.	231.
	2.	33.	28.	29.5	59.
	1.	28.	16.	24.5	24.5
	1.	16	8.	18.	18.
	0.5	8.	0.	11.	11.
	20.				479.5

$\frac{479 \cdot 5}{20} = 24$, average speed m.p.h. between Conrad and Stein's Pass for load of 65 M's per M of power.

Wherever practicable an operating profile is plotted for maximum and minimum loads per unit of power and the average speed determined. These speeds and loads are again plotted, their curve determined and the intermediate loads and velocities interpolated, and Table II thus made complete for all loads and velocities coming within the limits assumed.

In plotting the operating profile, it remains to be noted that during acceleration the profile is a curve, which changes by infinitesimal increments and does not change suddenly, as shown on the drawing. The smaller the distance taken along which any assumed acceleration continues, the more closely will the operating profile approach its actual form. In laying off the line which represents the retardation at every station, a braking effort of 90 pounds per M has been assumed. This corresponds to a grade of retardation of 9.0%. This grade, divided into the velocity head of the speed when the brakes are applied, will give the distance run in coming to rest, assuming that steam is shut off when brakes are applied.

There is a theoretical error in this method, in that it is tacitly assumed that through any one of the short sections over which the operating profile is on a constant grade the train

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* The average speed for any given portion is obtained by transforming the velocity heads at the beginning and end of each portion into speed in miles per hour by Table I, taking their sum and dividing by 2.

resistance and traction are constant and are those due to the final velocity at the end of that grade, when, in point of fact, both are constantly changing unless the operating grade happens to be parallel to the track grade (i. e., the speed is uniform). The effect of this inaccuracy is to somewhat lower the operating profile for all operating grades greater than track grades, and to somewhat raise the operating profile when the operating grades become less than the track grades. The only cases in which this error need be considered are in approaching heavy up-grades at high speeds and heavy down-grades at low speeds.

This error may be diminished to as small dimensions as may be desired by making the sections sufficiently short. For the conditions considered, we find that the operating profiles, laid out in reasonably short sections, are sufficiently accurate for practical purposes. It would be more nearly accurate to take the train resistance and traction as those due to the average speed over the space considered. The operating profile may also be laid out by calculating the velocity and height due to velocity at the end of each short section. Formulæ for this purpose, expressing the height and velocity in terms of the corresponding average (or final) traction, grade and train resistance, and initial velocity, may be derived as follows:

Let T=traction.
G=grade resistance ($\pm$).
R=train resistance.
F=accelerating force$=T-(G+R)$.
S=space considered (during which the above are assumed constant).
W=load$=1{,}000\times M$'s.
h=height in feet at end of space S.
h^1=height in feet at beginning of space S.
V=velocity in feet per second at end of space S.
V_1=velocity in feet per second at beginning of space S.
I=Increase ($\pm$) of height for space S.

For the short space S, the acceleration ($\pm$) is regarded as constant. Since the work done by the force F over the space S equals the lift I times the weight, we have:

$$F\ S=W\ I=W\ (h-h^1) \qquad (1)$$

$$h=\frac{F\ S}{W}+h^1 \qquad (2)$$

From (2) h may be obtained.

$$h = \frac{V^2}{2\,g} \text{ and } h^1 = \frac{V_1^2}{2\,g} \text{ substituting in } (2)$$

$$V = \sqrt{\frac{2\,g\,F\,S}{W} + V_1^2} \qquad (3)$$

From (3) the final velocity V may be calculated.

Formula (1) may be generalized thus:

$$\Sigma\,F\,S = \Sigma\,S\,T - \Sigma\,S\,(G+R) = \Sigma\,W\,I = W\,\Sigma\,I = W\,h$$

That is, from the start up to any point, the potential minus the sum of all space-resistances equals the load times the final height. This principle furnishes a ready check upon the accuracy of the entire work up to any point.

A time-load diagram from Lordsburg to Tucson, M. W. D. 1107 B, with accompanying memorandum on blank M. W. D. 1109 F, drawings of which are shown, illustrates the way in which the results obtained may be made of service in the preparation of locomotive rating tables, and is self-explanatory.

GROUPING OF ENGINES

According to ratio of Length of Piston Stroke to Diameter of Driver, showing also average ratios assumed for the different groups.

M. W. D.
1109
A

Length of Stroke. Inches.	Diameter of Driver. Inches.	Average Ratio.	Group Number.	Length of Stroke. Inches.	Diameter of Driver. Inches.	Average Ratio.	Group Number.
22	48	.447	VI	24	62	.397	VIII
22	54	.397	VII	24	63	.376	IX
22	56	.397	VIII	24	64	.376	IX
22	57	.376	IX	24	69	.335	X
22	60	.376	IX	26	51	.517	III
22	63	.335	X	26	55	.473	V
22	64	.335	X	26	63	.420	VII
22	68	.335	X	26	69	.376	IX
24	48	.490	IV	28	63	.447	VI
24	49	.490	IV	28	68	.420	VII
24	50	.490	IV	28	69	.397	VIII
24	51	.473	V	30	51	.589	I
24	53	.447	VI	30	54	.545	II
24	54	.447	VI	30	55	.545	II
24	56	.447	VI	30	56	.545	II
24	56	.420	VII	30	57	.517	III
24	57	.420	VII	30	63	.573	V
24	60	.397	VIII	32	55	.589	I
24	61	.397	VIII	34	57	.589	I

M. W. D.
1109
B .

LOCOMOTIVE RATING. JULY, 1899.

Table showing under each Group number of Engines, and opposite speed in miles per hour, the coefficient with which to transform the number of M's shown as hauled by Standard Engine (Group V) on Time Load Diagrams, to the number of M's for any other Engine *at the same speed* as indicated on Time Load Diagram.

For Engines in Groups I to IV inclusive use coefficient for the highest average speed, and for groups VI to X for the lowest average speed, between any two stations.

Miles per Hour	I		II		III		IV		V		VI		VII		VIII		IX		X		Groups
	.589		.545		.517		.490		.473		.447		.420		.397		.376		.335		Average Ratio $\frac{L}{D}$
	Simple	Compd	Simple	Compd	Simple	Compd	Simple	Compd	Simple	Compd	Simple	Compd	Simple	Compd	Simple	Compd	Simple	Compd	Simple	Compd	
		23"				20"20"												20"		20"	Dia. H.P. Cyl. Compds.
		35"				30"29"												29"		29"	Dia. L.P. Cyl.
10	.940	.920	.960		.970	.970	.980		1.0		1.000		1.000		1.000		1.000	1.070	1.000	1.100	
11	.930	.906	.954		.966	.960	.980		1.0		1.004		1.008		1.014		1.016	1.072	1.026	1.104	
12	.920	.892	.948		.962	.950	.980		1.0		1.008		1.016		1.028		1.032	1.074	1.052	1.108	
13	.910	.878	.942		.958	.940	.980		1.0		1.012		1.024		1.042		1.048	1.076	1.078	1.112	
14	.900	.864	.936		.954	.930	.980		1.0		1.016		1.032		1.056		1.064	1.078	1.104	1.116	
15	.890	.850	.930		.950	.920	.980		1.0		1.020		1.040		1.070		1.080	1.080	1.130	1.120	
16	.882	.838	.924		.946	.912	.978		1.0		1.022		1.046		1.078		1.090	1.084	1.140	1.130	
17	.874	.826	.918		.942	.904	.976		1.0		1.024		1.052		1.086		1.100	1.088	1.150	1.140	
18	.866	.814	.912		.938	.896	.974		1.0		1.026		1.058		1.094		1.110	1.092	1.160	1.150	
19	.858	.802	.906		.934	.888	.972		1.0		1.028		1.064		1.102		1.120	1.096	1.170	1.160	
20	.850	.790	.900		.930	.880	.970		1.0		1.030		1.070		1.110		1.130	1.100	1.180	1.170	
21	.842	.780	.894		.926	.874	.968		1.0		1.032		1.076		1.118		1.140	1.104	1.196	1.180	
22	.834	.770	.888		.922	.868	.966		1.0		1.034		1.082		1.126		1.150	1.108	1.212	1.190	
23	.826	.760	.882		.918	.862	.964		1.0		1.036		1.088		1.134		1.160	1.112	1.228	1.200	
24	.818	.750	.876		.914	.856	.962		1.0		1.038		1.094		1.142		1.170	1.116	1.244	1.210	
25	.810	.740	.870		.910	.850	.960		1.0		1.040		1.100		1.150		1.180	1.120	1.260	1.220	
26	.796	.730	.862		.906	.848	.958		1.0		1.042		1.106		1.158		1.190	1.126	1.276	1.232	
27	.782	.720	.854		.902	.842	.956		1.0		1.044		1.112		1.166		1.200	1.132	1.292	1.244	
28	.768	.710	.846		.898	.838	.954		1.0		1.046		1.118		1.174		1.210	1.138	1.308	1.256	
29	.754	.700	.838		.894	.834	.952		1.0		1.048		1.124		1.182		1.220	1.144	1.324	1.268	
30	.740	.690	.830		.890	.830	.950		1.0		1.050		1.130		1.190		1.230	1.150	1.340	1.280	
31	.724	.680	.822		.884	.826	.948		1.0		1.052		1.136		1.198		1.240	1.160	1.360	1.298	
32	.708	.670	.814		.878	.822	.946		1.0		1.054		1.142		1.206		1.250	1.170	1.380	1.316	
33	.692	.660	.806		.872	.818	.944		1.0		1.056		1.148		1.214		1.260	1.180	1.400	1.334	
34	.676	.650	.798		.866	.814	.942		1.0		1.058		1.154		1.222		1.270	1.190	1.420	1.352	
35	.660	.640	.790		.860	.810	.940		1.0		1.060		1.160		1.230		1.280	1.200	1.440	1.370	

The diagram is based upon locomotives (Group V) of 26-inch stroke of piston and 55-inch diameter of drivers, or a ratio of stroke divided by diameter of .473. For engines having different ratios of piston stroke divided by driver diameter, reference is made to Tables M. W. D. 1109 A and M. W. D. 1109 B, attached. In these tables all locomotives having approximately the same ratio of stroke to driver diameter are placed in the same rating class.

In applying this method, the fact that in the course of service driving wheel diameters, and, to some extent, cylinder dimensions, are changed by wear has been taken into consideration, and for convenience in grouping the locomotives, differences in ratios of from 1 to 8 per cent have been disregarded. For example, engines having ratios varying from .471 to .476 have been put in Group V, and engines with ratios varying from .323 to .348 have been put together in Group X. See Table M. W. D. 1109 A.

Engines in Group V being taken as unity at all speeds, the comparative hauling power of engines in other groups at corresponding speeds can be expressed by a coefficient. For example, if at 10 miles per hour a rating Group V engine can haul a given number of M's per unit of power, expressed as unity, an engine in Group I will haul a load equal to .94.

All engines from Group VI to Group X, inclusive (under the assumption that the percentage of mean effective pressure is the same at 10 miles per hour as for Group V class), will haul the same load at 10 miles per hour as the Group V class. At 15 miles per hour, the load with Group V class being unity, the load with Group I class becomes .89 and the load with the Group X class 1.13. This is expressed in Table M. W. D. 1109 B for speeds ranging from 10 to 35 miles per hour. In applying this table for exact results, determine time-load diagram for a standard rating engine (Group V). For engine Groups I to IV inclusive, use, to find corresponding M's of load, coefficient for the highest average speed (G) between any two stations on the run under consideration. This, as a rule, will slightly underload the engines Groups I to IV, especially so in cases where the highest speed applies only to short distances and is materially greater than the average speed for the entire run. For engines in Groups VI to X, inclusive, determine corresponding load by using coefficient (M) for the lowest average speed between any two stations on the run under consideration. The same remark as to the underloading of engines applies in this case, in a similar manner as to Groups I to IV, especially in cases where the *lowest* speed is for short distances and materially less than the average speed for the entire run. The reason for this is obvious from an inspection of Table M. W. D. 1109 B, since in Groups I to IV the coefficients decrease as the speed increases, while in Groups VI to X the coefficients increase as the speed increases.

In some cases "M" may be stated greater than "G," arbitrarily, with the view of rating mountain engines on the valley lines, under the supposition that such engines will not, as a rule, be misplaced, and when they are, temporarily, for any reason, something should be sacrificed in the way of making time, in order to work them nearer to their full capacity. In other words, the supposition is that the fast time freight will, as a rule, be hauled on each division by the engines best designed to make time economically.

In the practical application of this method, the greatest average speed, "G," between stations, shown in time-load diagrams, is not, in all cases, the maximum possible, with the specified load, per operating profiles (and Table II), but is reduced

a. By the adopted minimum running time, and

b. By a reduction, in some cases, below the maximum running time, where such reduction can be made consistently with the time allowable for the entire run. This method is used where mountain engine runs are located partly on steep grades and partly in valleys, and it is desired to rate them for slow running throughout, instead of for fast running on the valley sections; in other words, for their full power on the heaviest grades.

Therefore, the maximum speed between stations, used in connection with Table 1109 B, and stated on time-load diagrams, is generally the maximum speed, with engine working full power, and not the maximum speed possible on the level, on light ascending grades, or on descending grades. The least average speed between stations, "M," as stated on time-load diagrams, is determined in a similar way and with a view to rating engines for the speed between stations where they are worked full power.

GENERAL METHOD OF CALCULATING TABLES M. W. D. 1109 A AND B FOR SINGLE EXPANSION ENGINES.

Ratios for $\frac{L}{D}$ are calculated to three decimal places. For the 38 types of locomotives to be rated, these ratios vary from .596 to .323; the ratio for standard basing locomotive, Group V, being .473.

The 38 types of engines are arranged in 10 different groups, according to the proximity of their ratios $\frac{L}{D}$ and for each group an average ratio is adopted which is considered typical.

Group Number.	Ratio Ranging		Average Ratio Adopted.
	From	To	
I	.596	.582 inc.	.589
II	.555	.536 "	.545
III	.526	.509 "	.517
IV	.500	.480 "	.490
V	.476	.471 "	.473 (basis)
VI	.458	.436 "	.447
VII	.429	.412 "	.420
VIII	.407	.387 "	.397
IX	.386	.366 "	.376
X	.348	.323 "	.335

Multiplying adopted ratio by 56x (see formula, page 6), we obtain the different piston speeds for corresponding train speeds, and from Table I we find by inspection the traction corresponding to piston speed and the resistance due to train speed and grade. Dividing this traction by this resistance, the quotient is M's of load per unit of power for the group of locomotives under consideration. Dividing this quotient by M's of load for the same train speed and grade in Table I, the quotient is a ratio applicable to convert loads in Table I to loads for all locomotives in the group considered.

These conversion ratios, per Table M. W. D. 1109 B, are constant and independent of variations in grade, because in calculation of Table I and in above operations, the addition of the grade resistance to the train resistance merely reduces, in the same proportion, the load of both Table I and of the groups considered, and thus the effects of such grades are eliminated in the final quotient or ratio. All this amounts to the same thing as finding the ratio of the traction (column 3, Table I), of any group to that of Group V at the same train speed.

CALCULATION OF LOCOMOTIVE RATING TABLE M. W. D. 1109 B, FOR COMPOUND ENGINES.

Assume any boiler pressure. Take the mean effective pressure for each cylinder from diagram P. S. M. 1171. Find the traction of compound locomotive at 265 feet per minute piston speed. Adopt a divisor which will reduce this total traction to the figure 1,000. Find the total traction of engine at other piston speeds corresponding to miles per hour for which each coefficient is desired. Divide this total traction by the above divisor. The resulting ratio represents the comparative traction at different speeds. Divide each ratio obtained as above by the traction at the same train speed of basic Group V per Table I.

Example, compound locomotive:

High pressure cylinder diameter	23″
Low " "	35″
Stroke	34″
Driver	57″

Train Speed, Miles Per Hour.	Piston Speed, Feet Per Min.	M. E. P. (Boiler Press 100.)		Traction $\frac{d^2 L p}{2 D}$		Total Traction.	Traction Ratios.	Group V Traction.	Final Coefficient.
		High P.	Low P.	High P.	Low P.				
	265	61.4	30.7	9579	11207	20886	1000		
10	337	56.4	28.5	8890	10404	19295	924	1000	.924
20	674	34.	19.0	5360	6936	12296	590	750	.790
30	1011	20.	11.7	3153	4271	7424	356	535	.676

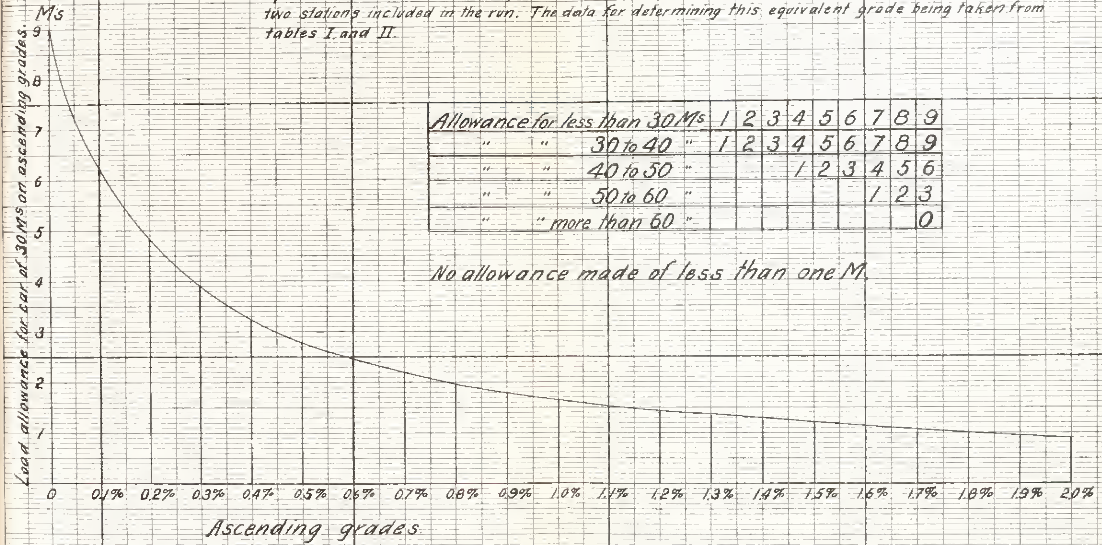
The immaterial difference between these final coefficients and those set down in Table M. W. D. 1109 B is accounted for by the fact that in this calculation the actual ratio for this particular engine's stroke of piston to diameter of driver was used, while the table is based upon the average ratio of Group I, in which group this engine is placed, although not having the exact ratio of .589.

Locomotive Rating

Load allowance for empty and underloaded cars.

MWD
1109
E

For each engine run the allowance for empty cars should be based on the ascending grade equivalent to the fastest average time made (with Engine working under steam) between any two stations included in the run. The data for determining this equivalent grade being taken from tables I. and II.



Allowance for less than 30 M's	1	2	3	4	5	6	7	8	9
" " 30 to 40 "	1	2	3	4	5	6	7	8	9
" " 40 to 50 "				1	2	3	4	5	6
" " 50 to 60 "							1	2	3
" " more than 60 "									0

No allowance made of less than one M.

HELPING ENGINE POWER.

For through road engine rating, based on use of "helpers," the ratio of helper power to road engine power is determined as follows:

Weight in M's of standard "helpers" per unit of power $= W$
Weight of train, including engine and tender, at foot of helper grade, per unit of power............. $= U$
M's per unit of power haulable up grade........... $= G$
M's of load, exclusive of helper engine and tender, to be hauled up grade by helpers................ $= U - G = H$
M's, exclusive of engine and tender, that can be hauled up given grade per unit of power....... $= G - W = n$
Ratio helper to road engine....................... $= \frac{H}{n} = R$

Example: If $W = 10$
$U = 100$
$G = 40$
then $H = 60$
$n = 30$
and $R = 2$

In other words, 100 M's per unit of road engine power can be hauled up the given grade if helping engines are coupled in to exert twice the total power of the road engine. In this example we have 100 M's to foot of grade hauled by one unit and 120 M's hauled by three units, each unit hauling 40 M's.

RESISTANCE OF AND CONSTRUCTIVE WEIGHT ALLOWANCE FOR EMPTY AND UNDERLOADED CARS.

If we assume the resistance of loaded cars on a level at 2.4 pounds per M, the resistance of empty cars at the same speed at 30% greater or 3.12 pounds per M, the total resistance for 39 M's of loaded cars will be 93.6 pounds, and for 30 M's of empty cars 93.6 pounds. If, therefore, we express the additional resistance of the empty car by constructively increasing its weight, then the total resistance of 30 M's of empty cars, constructively increased to a rating weight of 39 M's of loaded cars, would be 93.6 pounds, as before.

On the foregoing assumption, the resistance of 30.96 M's of loaded cars at 10 miles per hour on a 2% grade is (at 22.4 pounds per M) 693 pounds. The resistance of 30 M's of empty cars at 10 miles per hour, on a 2% grade (at 23.12 pounds per M), is 693 pounds. If, therefore, a constructive weight allowance of about 3.3% be made for empty cars on a 2% grade, calling an empty car weighing 30 M's equal to 31 M's of loaded cars, the total resistance of the actual 30 M's of empty cars is 694 pounds, practically as above.

This method and diagram, 1109 E, is based on the fact that only the rolling and atmospheric resistances are greater per weight unit of empty cars than per weight unit of loaded cars.

To make the time determined by the foregoing methods with empty cars for each "engine run," the allowance for empty cars may, with practical accuracy, be based on the ascending grade, equivalent to the fastest average time made (with engine working under steam) between any two stations included in the run; the data for determining this equivalent grade being taken from Tables I and II. For example, if, as indicated by Table II, the fastest average time with engine working under steam and hauling 100 M's per M of power, between any two stations on its run, is 20 miles per hour, then, by reference to Table I, it will be seen that 100 M's per M of power can be hauled at 20 miles per hour on a + 0.4% grade. The weight allowance for empty cars will be accordingly based on this equivalent grade, which for 30 M's, per Table 1109 E, is 3 M's. This allowance of 3 M's is considered to apply to empty cars weighing less than 30 M's and to empty or underloaded cars weighing from 30 to 40 M's, making for these conditions

Allowance for less than 40 M's	3 M's
From 40 to 50 M's	0
" 50 " 60 "	0

The allowance resulting from this rule is compared with that required for the limiting grade of the run, the minimum allowance. A study is then made to determine whether under this minimum allowance trains composed entirely of empty cars will stall between any two stations. If found that they will, then the proper allowance to avoid such stalling is adopted, the effect in time-load diagram for the run ascertained and the time line modified accordingly. For illustration: If between stations A and B the distance is 10 miles, the grade level, the speed 20 miles per hour, the running time 30 minutes and the load per unit of power 214 M's, the required constructive weight allowances (9 M's over 30 M's) 30%, and the adopted weight allowance (2 M's over 30 M's) 6.66%, then the required additional or constructive weight of 214 actual M's of empty cars is 214 + 64 M's = 278 M's, but $\frac{2}{9}$ = 14 M's having been provided for, the resistance of the empty cars is equal to 214 + 50 = 264 M's of loaded cars. By Table II (reading to nearest half mile) the speed corresponding to 264 M's is 17 miles an hour and the running time 35 minutes. For safe rating the time-load diagram and its accompanying memorandum is accordingly based on 17 instead of 20 miles per hour.

In these computations, the fact is remembered that the resistance of engine, tender and caboose remains constant, but this, thought to involve unnecessary refinement, is not considered.

The constructive weight allowance for light descending grades is also considered to be the same as for level grades.

REVISION OF GRADES.

The application of the foregoing methods to grade reduction will be obvious without further explanation. The attached operating or tonnage rating profile, drawing M. W. D. 1102 R. R., will illustrate the application of the method to a division where the line traverses a valley some 300 miles in length, which has a maximum rise in long stretches of $\frac{4}{10}$%. It is, therefore, feasible, by reducing the grades to $\frac{4}{10}$% or the equivalent of that rate, to haul 157 M's (157,000 pounds) per unit of power.

The attached leaf, T. R. 6-1, illustrates rating sheets as issued by Mr. F. W. Mahl, mechanical engineer, to the division officers, and through them to the train dispatchers, yardmasters and conductors.

The potential, which is merely the tonnage rating in tons of 2 M's, multiplied by the distance in miles, is inserted for the convenience of the division officers in figuring the percentage of potential gotten out of their power. The other notes on leaf T. R. 6-1 are self-explanatory.

In addition to this regular rating (T. R. 6-1) there is furnished to the division officers "single engine rating," giving them the rating for each class of locomotives for each run without the use of helpers or of doubling up summits. This puts it in their power to determine whether the volume of traffic over any one run is sufficient to justify them in putting on a helper and increasing the rating to the regular through capacity.

For the sake of completeness the following example is given of the method by which T. R. 6-1 is calculated:

Example:

Mogul engine—Class E.D. Nos. 1440 to 1469—on run Tucson to Benson, through freight. Train 7-8 on Time Load Diagram 1107 B.

Cylinder diameter....................20″
Piston rod " ....3.143″
Stroke..............................28″
Driver diameter....................63″
Group...........................VI. (1109 A)
Weight, engine and tender loaded ....245.1 M's
Caboose.................... ... 33.2
278.3 M's

Boiler pressure .... 190 lbs.
Piston speed at 10 m.p.h. train speed....(Formula page 6)

$$\frac{10 \times 56 \times 28}{63} = 250 \text{ feet per minute, nearly}$$

Mean effective pressure at 250 feet per minute piston speed........................(P.S.M. 1023)

$$= 0.81 \times 190 = 153.9 \text{ lbs.}$$

$$\text{Traction units} = \frac{\left[20^2 - \frac{(3.143)^2}{2}\right] \times 28 \times 153.9}{63} \text{ (Formula page 7)}$$

$$= 27.022 \text{ M's}$$

Tucson to Benson—Train 7-8..........(M.W.D. 1109 F)
110 M's per M of power
Coefficient for Engine Groups VI at 12 m.p.h.
=1.008........................(M.W.D. 1109 B)

Gross tonnage = 27.022 × 110 × 1.008
= 2988.3 M's
Engine, tender and caboose..... 278.3 "
Engine tonnage rating=........ 2710 M's net (T.R.6–1)

H.W.B.
1109
C

Locomotive Rating

Table I

June 1899

Train Load in M^s including engine tender and cars, which can be hauled at given speeds on given grades per unit of power by a Locomotive having 26" piston stroke and drivers 55" in diameter (Group V engine)

One unit of power – Tractive effort of 1000 lbs at point of contact between driving wheels and rails at a train speed of 10 miles per hour for Group V engine
1000 lbs of load = 1 M.

A	1	2	3	4		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	2	1
Piston speed feet per minute Group V engine	Miles per hour Group V engine	Velocity head	Traction Group V engine	Train Res per M	Grade actual or equival	Level	+0.1	+0.15	+0.20	+0.25	+0.3	+0.4	+0.5	+06	+0.75	+1.0	+1.25	+1.4	+1.5	+1.6	+1.7	+1.8	+1.9	+2.0	+2.1	+2.2	+2.3	+2.4	+2.5	+3.0	+3.3	−0.9	−0.75	−0.6	0.5	0.4	−0.3	−0.2	−0.1	−0.05	Velocity head	Miles per hour Group V engine
					Grade resistance per M	0	1	1^{5}	2	2^{5}	3	4	5	6	7^{5}	10	12^{5}	14	15	16	17	18	19	20	21	22	23	24	25	30	33	9	7^{5}	6	5	4	3	2	1	0^{5}		
265	10	3^{5}	1000	2^{4}		416	292	256	227	204	185	157	135	119	101	81	67	62	58	54	51	49	47	45	43	41	39	38	36	31	28								715	526	3^{5}	10
291	11	4^{3}	975	2^{45}		398	282	246	219	194	177	152	131	115	98	78	65	60	56	53	50	48	45	43	41	40	38	37	35	30	27								610	500	4^{3}	11
318	12	5^{1}	950	2^{5}		380	272	238	210	190	173	146	127	112	95	76	64	58	54	51	48	46	44	42	40	39	37	36	35	30	27								630	475	5^{1}	12
344	13	6	925	2^{6}		356	256	225	200	181	165	140	122	107	92	73	61	56	53	49	47	45	43	41	39	37	36	35	34	29	26								580	438	6	13
371	14	7	900	2^{75}		327	240	211	188	172	156	133	116	103	88	71	59	54	51	48	45	43	41	40	38	36	35	34	32	27^{6}	25								518	400	7	14
397	15	8	875	2^{9}		302	222	198	178	162	148	127	110	98	84	68	57	52	49	46	44	42	40	38	36	35	34	32	31	26^{6}	24								460	364	8	15
424	16	9	850	3		284	210	188	170	154	141	121	106	94^{5}	81	64^{5}	55	50	47	45	42	40	39	37	35	34	33	31	30	26^{3}	24								425	340	9	16
450	17	10^{3}	825	3^{1}		266	201	179	163	147	135	116	102	91	78	63	53	48	45	43	41	39	37	36	34	33	32	30	29	25^{3}	23							750	392	315	10^{3}	17
477	18	11^{5}	800	3^{25}		246	186	168	152	139	128	110	97	87	75	60	51	47	44	42	39	38	36	34	33	32	30	29	28	24^{3}	22							640	334	291	11^{5}	18
503	19	12^{8}	775	3^{4}		228	176	158	143	131	121	105	92	83	71	58	49	45	42^{5}	40	38	36	35	33	32	30	29	28	27	23^{3}	21							565	322	267	12^{8}	19
529	20	14^{2}	750	3^{55}		214	167	150	136	125	115	100	88	78	68	56	47	43	40^{5}	38	36	35	33	32	31	29	28	27	26	22^{3}	20							500	300	250	14^{2}	20
556	21	15^{7}	725	3^{7}		196	157	138	126	116	107	93^{5}	83	74^{5}	64	53	44^{5}	41	38^{6}	37	35	34	32	31	29	28	27	26	25	22	20							415	264	226	15^{9}	21
582	22	17^{2}	700	3^{9}		180	142	130	118	109	101	88	79	71	61	50	42^{5}	39^{2}	37	36	34	32	30	29	28	27	26	25	24	21	19						780	368	240	206	17^{2}	22
609	23	18^{8}	675	4^{1}		165	132	120	110	102	95	83	74	67	58	48	41	37^{5}	35^{4}	34	32	31	29	28	27	26	25	24	23	20	18						615	320	218	187	18^{8}	23
635	24	20^{5}	655	4^{25}		154	125	113	105	97	90	79	71	64	56	46	39	36	34	32	31	30	28	27	26	25	24	23	22	19^{5}	18						575	290	201	174	20^{5}	24
662	25	22^{2}	635	4^{4}		144	117	107	99	92	86	76	67^{5}	61	53^{5}	44	37^{5}	34^{6}	32^{7}	31	30	28	27	26	25	24	23	22	21^{5}	18^{5}	17						435	264	187	163	22^{2}	25
688	26	24	615	4^{5}		136^{5}	111	104	95	88	82	72	65	59	51	42^{5}	36	33^{3}	31^{6}	30	28	27	26	25	24	23	22	21	20	17^{5}	16						410	246	175	154	24	26
715	27	25^{9}	595	4^{75}		125	103	95	87	82	77	68	61	55	47^{5}	40	34^{5}	31^{8}	30	28	27	26	25	24	23	22	21	20^{5}	20	17	16					790	344	216	158	140	25^{9}	27
741	28	27^{8}	575	5^{00}		115	96	88	82	77	72	64	57^{5}	52	46	38	33	30	28^{6}	27	26	25	24	23	22	21	20	19^{7}	19	16^{5}	15					575	287	192	144	127	27^{8}	28
768	29	29^{9}	555	5^{25}		105	89	82	77	72	67	60	54	49	44	36	31	28^{6}	27	26	25	24	23	22	21	20^{1}	19^{4}	18^{7}	18	15^{5}	14					445	246	170	130	117	29^{9}	29
794	30	32	535	5^{5}		97	82	76	71	67	63	56	51	46	41	34	30	27^{3}	26	25	24	23	22	21	20	19^{1}	18^{4}	17^{2}	17	14^{8}	13^{5}					360	214	153	119	107	32	30
821	31	34	515	5^{75}		90	76	71	67	63	59	53	48	44	39	33	28	26^{2}	25	24	23	22	21	20	19^{1}	18^{4}	17^{7}	17	16^{5}	14^{3}	13				690	292	187	137	109	98	34	31
847	32	36^{4}	495	6^{00}		83	71	66	62	58	55	49^{5}	45	41	37	31	26^{8}	24^{8}	23^{6}	23	22	21	20	19	18	17^{5}	17	16^{5}	16	14^{1}	12^{5}				435	247	165	124	99	90	36^{4}	32
874	33	38^{7}	475	6^{25}		76	66	62	58	54	51	46	42	39	36	29	25	23^{6}	22^{6}	21^{5}	20^{5}	19^{7}	19	18^{3}	17	16^{5}	16	15^{5}	15	13^{1}	12				380	210	145	111	91	83	38^{7}	33
900	34	41	455	6^{5}		70	61	57	53^{5}	51	48	42^{5}	40	56^{5}	32	27^{5}	24	22^{3}	21^{2}	20	19	18^{8}	18	17^{2}	16^{4}	15^{5}	15	14^{5}	14	12^{5}	11^{5}				300	182	130	101	83	76	41	34
927	35	43^{6}	436	6^{75}		65	56	53	49	47	45	40	37	34	30	26	22^{6}	21	20	19	18^{5}	18	17	16	15^{5}	16	14^{5}	14	13^{5}	12	11			580	250	158	116	92	76	70	43^{5}	35
953	36	46	417	7^{00}		60	52	49	46	44	42	38	35	32	29	25	21	19^{8}	19	18	17^{6}	17	16	15^{5}	15	14^{5}	14	13^{5}	13	11^{5}	10^{5}			417	210	139	104	82	70	64	46	36
979	37	48^{5}	398	7^{25}		55	48	45^{5}	43	41	39	35	32^{5}	30	27	23	20	18^{8}	18	17	16^{5}	16	15^{5}	15	14^{5}	14	13^{5}	13	12^{5}	10^{8}	10			320	177	123	94	76	64	59	48^{6}	37
1006	38	51^{3}	378	7^{50}		51	45	42	40	38	36	33	30	28	25	21^{6}	18^{8}																	250	151	108	84	69	58	54	51^{3}	38
1032	39	54	363	7^{75}		47	41^{5}	39	37	35^{5}	34	31	28^{5}	26^{5}	23^{8}	20^{2}	18																	208	132	97	76	63	54	50	54	39
1059	40	56^{8}	347	8^{00}		43	38	36^{5}	35	33	31^{5}	29	26^{6}	24^{8}	22^{4}	19^{2}	16^{9}																694	174	116	87	69	58	50	46	56^{8}	40
1085	41	59^{7}	332	8^{4}		39^{5}	35	33^{5}	32	30^{5}	29	26^{6}	24^{8}	23	20^{8}	18	15^{9}																370	138	98	75	61	52	45	42	59^{7}	41
1112	42	62^{6}	316	8^{75}		36	32^{3}	30^{8}	29^{4}	28	26^{8}	24^{8}	23	21^{4}	19^{4}	16^{8}	14^{8}																260	115	84	66	55	47	40	38	62^{6}	42
1138	43	65^{6}	301	9^{2}		33	29^{6}	28	27	26	24^{6}	23	21^{2}	19^{8}	18	15^{7}																	172	94	72	58	48	42	37	35	65^{6}	43
1165	44	68^{7}	285	9^{5}		30	27^{2}	26	25	23^{6}	22^{8}	21	19^{6}	18^{4}	16^{7}	14^{6}																	143	92	63	52	44	38	33^{6}	32	68^{7}	44
1191	45	72	270	9^{9}		27^{4}	25	23^{6}	22^{6}	21^{8}	21	19^{4}	18^{1}	17	15^{5}	13^{6}																	112	69	55	46	39	34	30^{4}	29	72	45
1218	46	75	254	10^{25}		24^{8}	23^{6}	21^{6}	20^{7}	19^{8}	19^{3}	17^{6}	16^{6}	15^{6}																			92^{5}	60	48	41	35	31	27^{5}	26	75	46

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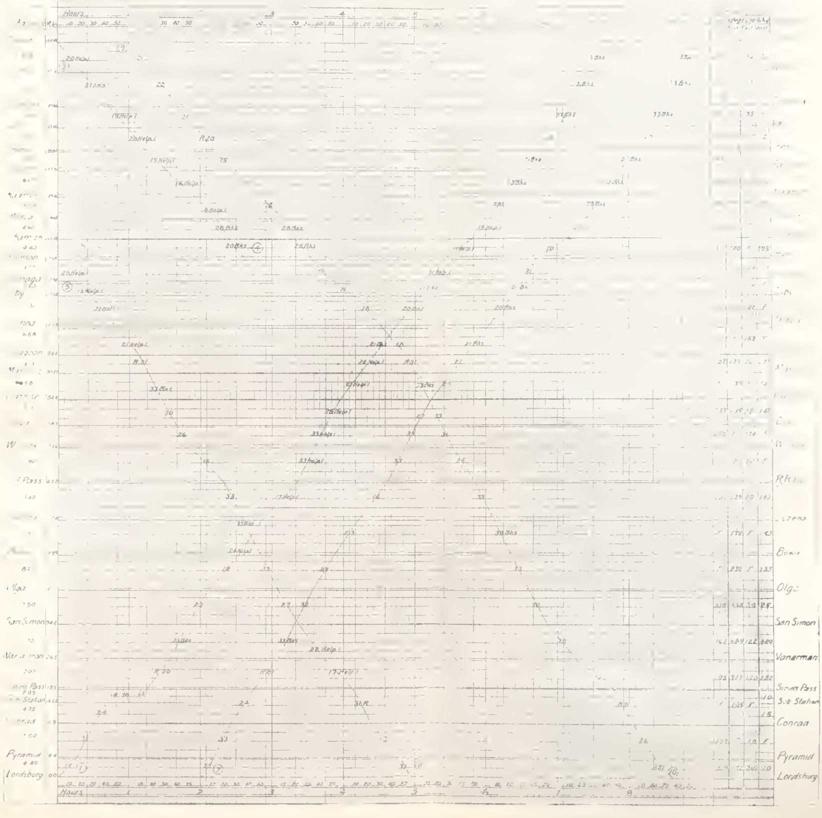
Time Load Diagram
Tucson Division



While the constants of some of the formulæ involved in this tonnage rating are taken from the train resistance curves in Wellington's Economic Theory of Railway Location (1900), and from an assumed mean effective pressure curve, P. S. M. 1171 and P. S. M. 1023, it is evident that this system is equally applicable to any assumed curves for train resistance and for mean effective pressure.

The "operating" profile (sometimes called the "virtual," "equivalent" or "velocity head" profile) has been treated of by Wellington and other authors, but for the purpose in hand, it is thought advisable to go somewhat fully into this (page 7) in order to render this article complete in itself.

If greater accuracy of coefficient (M. W. D. 1109 B) is desired there may be a fuller subdivision into groups than that adopted in M. W. D. 1109 A, even to the extent of making a coefficient for each ratio of stroke to driver diameter.

MEMORANDUM TO ACCOMPANY TIME LOAD DIAGRAM.

M. W. D.
1109
F.

Tucson Division. Drawing M. W. D. 1107 B August, 1900.

Time Line.	Class of Freight Train.	Loads in M's per Unit of Power.	SPEED—MILES PER HOUR.					ALLOWANCE FOR EMPTY OR UNDERLOADED CARS.			TIME BETWEEN TERMINAL STATIONS.					
											EXCLUSIVE OF STOPS.		WITH STOPS AVERAGING			
													½ Min. per Mile.		Min. per Mile.	
			Max.	Min.	M.	A.	G.	Less than 40 M's.	40 to 50 M's.	50 to 60 M's.	Hours.	Min.	Hours.	Min.	Hours.	Min.
1-2	Through	100	35	10	11	21.76	27	3	0	0	7	38	9	01	..	..
3-4	Through	110	35	10	15	18.46	21	3	0	0	2	38	3	03	..	..
5-6	Through	90	35	10	15	23.44	26	3	0	0	4	56	5	54	..	..
7-8	Through	58	35	10	10	23.60	26	3	0	0	6	58	8	21	..	..
9-10	Through	57	35	10	11	21.92	26	3	0	0	7	30	8	53	..	..

Rating based on start from rest at all stations.

All time lines based on trains of empty cars.

Max.=Highest speed at any point in miles per hour.

Min.=Lowest speed on ruling grades in miles per hour.

M.=Least average speed between any two stations in miles per hour—used with table 1109 B.

A.=Average speed for whole distance (excluding stops) in miles per hour.

G.=Greatest average speed between any two stations in miles per hour—used with table 1109 B.

Unit of Power.=1000 lbs. of tractive force at driving wheel rail contact.

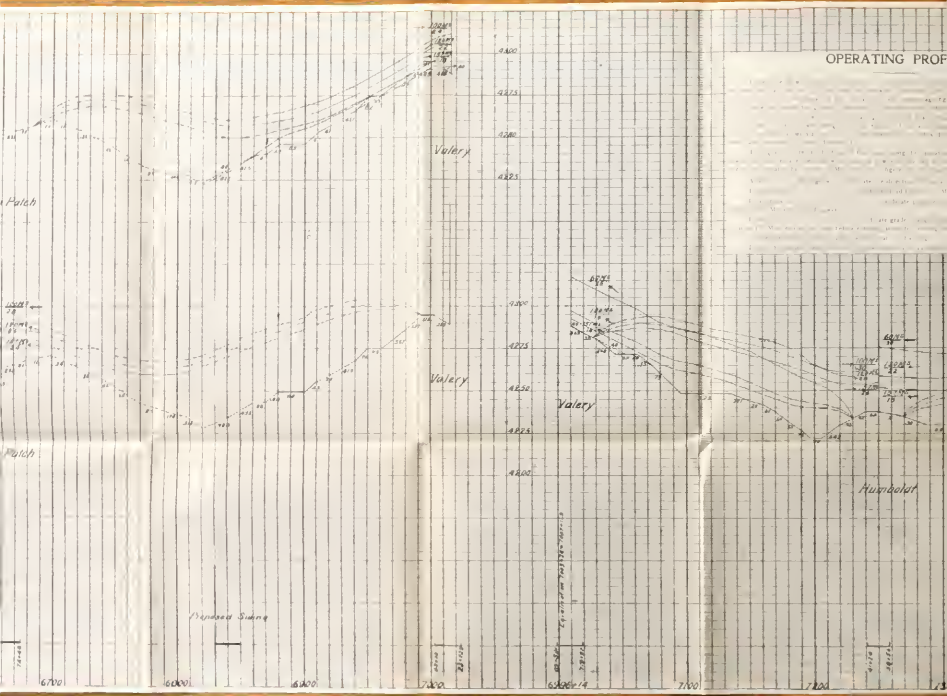
Figures on time lines between stations indicate average speed in miles per hour. R—That possible speed has been reduced by Min. Time of Time Table. Word "brakes," that brakes are used to hold speed under max. speed of 35 miles per hour between these stations.

Expression "Helper 1" means helper must have same power as road engine. "Helper .75" means helper must have ¾ of power of road engine. "Helper 2.3" means helper must have $2\frac{3}{10}$ times power of road engine, etc.

To find max. load that can be hauled at slow speed (10 m. p. h. on ruling grades) between any two stations, multiply rating for through freights by figure in column headed "Intermediate Rating."

"F" indicates that the full number of cars composing a max. train can be hauled. When "Intermediate Rating" load between any two stations makes a total loading exceeding the max. number of cars permissible in a train, the train hauled will be kept within the limiting number of cars.

Potential ton mileage will be based on through rating for each class of trains.



OPERATING PROF

RATING OF LOCOMOTIVES. TUCSON DIVISION. TUCSON TO LORDSBURG

Sept. 6, 1900. T. R. 6-1.
SHEET No. 5.

In M's of 1,000 lbs. between Tender and Caboose. Rating based on using Helper. See note below.

No. of SHEETS, 7.

CLASS.	ENGINE NUMBERS.	TUCSON TO BENSON. Through Freight. Rating.	TUCSON TO BENSON. Through Freight. Potential Ton Miles.	BENSON TO LORDSBURG. Through Freight. Rating.	BENSON TO LORDSBURG. Through Freight. Potential Ton Miles.	TUCSON TO BENSON. Local Freight. Rating.	TUCSON TO BENSON. Local Freight. Potential Ton Miles.	BENSON TO LORDSBURG. Local Freight. Rating.	BENSON TO LORDSBURG. Local Freight. Potential Ton Miles.
E. D.	1440 to 1498	2710	66097	2010	116258	2710	66157	2710	156746
D. A.	1808 to 1846	2390	58292	1910	110474	2520	61462	2520	145756
D. X.	1847 to 1851	2470	60243	1970	113944	2605	63536	2605	150673
D. I.	1694 to 1712	1540	37560	1220	70564	1625	39633	1625	93990
D. J.	1726 to 1745	1650	40243	1310	75770	1740	42438	1740	100641
D. L.	1684 to 1693	1545	37682	1225	70854	1630	39755	1630	94279
D. M.	1658 to 1663, 1667, 1670, 1672, 1673, 1674, 1676	1555	37926	1240	71721	1640	40000	1640	94857
D. N.	1664, 1665, 1669, 1671, 1675, 1677	1655	40366	1315	76059	1745	42560	1745	100930
D. O.	1581, 1583, 1589, 1601 to 1607, 1609 to 1641, 1643 to 1653, 1655, 1656, 1657, 1678 to 1683	1555	37926	1240	71721	1640	40000	1640	94857
D. O.	1582, 1554, 1558, 1559	1565	38170	1250	72300	1650	40243	1650	95436
D. O.	1561, 1562, 1565	1360	33170	1075	62198	1375	33536	1375	79530
D. P.	1608, 1654	1655	40366	1315	76059	1745	42560	1745	100930
C. D.	1382 to 1386, 1388, 1389, 1391 to 1394, 1397, 1399, 1400, 1401	1605	39145	1275	73746	1540	37560	1540	89073
C. E.	1387, 1390, 1395, 1396, 1398	1380	33648	1090	63045	1395	34024	1395	80686
C. I.	1300, 1307, 1310, 1318, 1326, 1327	1340	32682	1065	61599	1360	33170	1360	78662
C. J.	1306	975	23780	765	14247	985	24024	985	56972
C. J.	1277, 1278, 1293, 1295 to 1299, 1301, 1308, 1309, 1311 to 1317, 1319 to 1324, 1328, 1330 to 1354	1195	29146	945	54658	1210	29512	1210	69986
C. J.	1304	1100	15829	870	50320	1115	27195	1115	64491
"Helper 1" means that Helper has same power as road engine. "Helper .75" means ¾ power of road engine, etc.		Helper 1. Tucson to Mescal.		Helper 1. San Simon to Stein's Pass.		Helper 1. Tucson to Mescal.		Helper 1.2. Benson to Dragoon. Helper .75. Willcox to R. R. Pass. Hepler 1.2, S. Simon to S. Pass, Double S. Sub-Station to Pyramid.	

Average weather conditions. Maximum speed at any point 35 miles per hour. Minimum speed 10 miles per hour.

ALLOWANCE FOR EMPTY AND UNDERLOADED CARS.									
	Less than 40 M's.	3		3		3		3	
	40 to 50 M's	0		0		0		0	
	More than 50 M's	0		0		0		0	

To find local rating between any two stations, multiply net through rating above by the coefficient opposite required stations (east or west as case may be) and add thereto the sum of the weights of engine, tender and caboose multiplied by the same coefficient, diminished by one (1).

"F" denotes full number of cars allowed, which must not be exceeded in any case.

STATIONS.	East.	West.	STATIONS.	East.	West.	STATIONS.	East.	West
Tucson and Wilmot	1.35	F.	Visnaga and Sibyl	1.14	F.	Bowie and Olga	F.	1.35
Wilmot and Esmond	1.35	F.	Sibyl and Ochoa	1.22	F.	Olga and San Simon	2.0	2.5
Esmond and Vail	1.35	F.	Ochoa and Dragoon	1.62	F.	San Simon and Vanarman	1.22	4.0
Vail and Irene	1.35	1.0	Dragoon and Manzoro	1.0	1.47	Vanarman and Stein's Pass	1.20	1.82
Irene and Pantano	1.35	F.	Manzoro and Cachise	F.	1.47	Stein's Pass and Sub Sta.	F.	1.0
Pantano and Kadmon	1.35	4.16	Cachise and Duval	2.20	1.47	Sub. Sta. and Conrad	F.	1.5
Kadmon and Mescal	1.35	4.16	Duval and Willcox	1.74	F.	Conrad and Pyramid	1.0	F.
Mescal and Chamiso	F.	1.10	Willcox and R. R. Pass	1.0	F.	Pyramid and Lordsburg	2.02	1.0
Chamiso and Benson	F.	1.05	R. R. Pass and Luzena	1.0	1.47			
Benson and Visnaga	1.24	1.14	Luzena and Bowie	F.	1.47			

APPENDIX.

ASSOCIATION AFFAIRS.

Synopsis of Minutes of the Board Meeting, held August 25, 1900.

At a meeting of the Board of Direction of the American Railway Engineering and Maintenance-of-Way Association, held in Chicago, Ill., August 25th, 1900, the vote on the proposition of holding a semi-annual or fall meeting of the Association was canvassed, and. after discussion. the Board decided that it would be inexpedient to hold a fall meeting during the present year, but to re-submit the question of holding semi-annual meetings in future to the membership at the next annual meeting.

The Secretary announced the following deaths of members since the date of the annual meeting :

L. H. Clarke, Consulting Engineer, Chicago, Ill., March 20th, 1900.

W. G. Curtis, Engineer Maintenance-of-Way, Southern Pacific Company (Second Vice-President of the Association), June 15th, 1900.

D. J. Casey, Chief Engineer Detroit & Mackinac Railway, June 19th, 1900.

The vacancy in the office of Second Vice-President of the Association. caused by the death of Mr. Curtis, was filled by the selection of Mr. Hunter McDonald, Chief Engineer of the Nashville, Chattanooga & St. Louis Railway, by the unanimous vote of the Board.

Mr. Julius Kruttschnitt. Fourth Vice-President and General Manager of the Southern Pacific Company, was unanimously elected a member of the Board of Direction in place of Mr. Hunter McDonald, elected Second Vice-President.

The Secretary submitted a list of applications for membership. received since the publication of the proceedings of the last annual meeting. which were approved. (A list of new members is given in detail on following pages.)

MEMBERSHIP—ADDITIONS.

ALLEN, C. FRANK,
Professor of Railroad Engineering, Massachusetts Institute of Technology, Boston, Mass.

ASHBY, E. B.,
Engineer Maintenance of Way, Lehigh Valley Railroad, South Bethlehem, Pa.

BARNARD, J. A.,
General Manager Peoria & Eastern Railway (C., C., C. & St. L. Railway, Lessee), Indianapolis, Ind.

BLAIKLOCK, M. S.,
Resident Engineer Eastern Division Grand Trunk Railway, Montreal, Canada.

BOUSCAREN, GUSTAVE,
Consulting Engineer—Chief Engineer Commissioners of Water Works, City Hall, Cincinnati, O.

BULLIS, S. S.,
Second Vice-President and General Manager Gulf & Ship Island Railroad, Gulfport, Miss.

CHASE, WENDELL N.,
Assistant Engineer Pacific Coast Company, 300 Burke Building, Seattle, Wash.

CLARK, J. M.,
Superintendent and Chief Engineer Boise, Nampa & Owyhee and Idaho Northern Railroads, Nampa, Idaho.

CLARKE, C. S.,
General Superintendent Mobile & Ohio Railroad, Mobile, Ala.

COWAN, H. W.,
Chief Engineer Colorado & Southern Railway, Denver, Colo.

DAILEY, JOHN C.,
Superintendent Illinois Central Railroad, Carbondale, Ill.

DILL, H. R.,
Assistant Superintendent, Louisville Division, Illinois Central Railroad, Evansville, Ind.

DIXON, J. M.,
Chief Engineer Bismarck, Washburn & Great Falls Railroad, Lock Box 425, Bismarck, N. D.

DUNN, D. B.,
Engineer of Bridges and Buildings, Tennessee Central Railway, Crossville, Tenn.

ELLIOTT, HOWARD,
General Manager Hannibal & St. Joseph; St. Louis, Keokuk & Northwestern; Kansas City, St. Joseph & Council Bluffs; Chicago, Burlington & Kansas City, 603 Globe-Dem. Bldg., St. Louis, Mo.

EMMERT, J. H.,
Assistant to President Santa Fe, Prescott & Phœnix Railway,
Prescott, Ariz.

FERRIS, H. C.,
Superintendent and Engineer Maintenance-of-Way, Toledo & Ohio
Central Railway, Columbus, O.

FLANDERS, J. B.,
General Superintendent Cincinnati Northern Railroad,
Toledo, O.

GARDNER, W. A.,
General Manager Chicago & Northwestern Railway,
22 Fifth Avenue, Chicago, Ill.

GOODE, J. V.,
General Superintendent Fort Worth & Denver City Railway,
Fort Worth, Texas.

HAMMOND, A. E.,
Chief Engineer, Columbia Southern Railway,
Shaniko, Ore.

HATCH, J. B.,
Chief Engineer Gulf & Ship Island Railroad,
Gulfport, Miss.

HERDEN, H.,
Chief Engineer Buffalo & Susquehanna Railway,
Galeton, Pa.

HUNTER, W.,
Chief Engineer Philadelphia & Reading Railway,
Reading Terminal, Philadelphia, Pa.

KILLEBREW, O. D.,
Assistant Engineer of Maintenance Southern Railway,
Greensboro, N. C.

KING, W. S.,
Chief Engineer Union Stock Yards & Railroad Company,
South Omaha, Neb.

KLINE, THEO. D.,
General Superintendent Central of Georgia Railway,
Savannah, Ga.

MCCARTNEY, H. M.,
Superintendent and Chief Engineer Arizona & Utah Railway,
Kingman, Ariz.

MCHENRY, E. H.,
Chief Engineer Northern Pacific Railway,
St. Paul, Minn.

MCKAY, OWEN,
Chief Engineer Lake Erie & Detroit River Railway,
Walkerville, Can.

MCNAUGHER, D. W.,
Civil Engineer,
Monongahela Bank Building, Pittsburg, Pa.

Mallory, S. H.,
President and General Manager Fulton County Railway.
Chariton, Iowa.

Montague, George,
Superintendent Track, Bridges and Buildings New Mexico & Arizona Railroad and Sonora Railway, Nogales, Ariz.

Moore, Robert,
Consulting Engineer,
Laclede Building, St. Louis, Mo.

Moore, W. H.,
Engineer of Bridges New York, New Haven & Hartford Railroad,
New Haven, Conn.

Morse, G. F.,
Assistant Engineer Lehigh Valley Railroad,
Buffalo, N. Y.

Mountcastle, G. A.,
Roadmaster Southern Pacific Company,
Deming, N. M.

Naugle, J. A.,
Assistant General Manager New Mexico & Arizona Railroad and Sonora Railway, Guaymas, Sonora, Mexico.

Neff, Nettelton,
Engineer Maintenance of Way, Pennsylvania Lines West,
Columbus, Ohio.

Paret, M. P.,
Chief Engineer Kansas City, Mexico & Orient Railway.
Seventh and Wyandotte Streets, Kansas City, Mo.

Pennington, Edmund,
General Manager Minneapolis, St. Paul & Sault Ste. Marie Railway, Minneapolis, Minn.

Phillips, H. C.,
Resident Engineer Atchison, Topeka & Santa Fe Railway,
Ottawa, Kas.

Randall, E. J.,
Engineer Maintenance-of-Way Toledo, St. Louis & Western Railroad, Frankfort, Ind.

Schneider, C. C.,
Vice-President American Bridge Company,
100 Broadway, New York, N. Y.

Shaw, A. M.,
Roadmaster, Illinois Central Railroad,
Council Bluffs, Iowa.

Snow, J. P.,
Bridge Engineer, Boston & Maine Railroad,
Boston, Mass.

Stimson, F. C.,
Assistant Engineer Chicago & Northwestern Railway.
Council Bluffs, Iowa.

Swain, G. F.,
Professor of Civil Engineering Massachusetts Institute of Technology, Engineer Mass. Railroad Commission, Member Boston Transit Commission, Boston, Mass.

Taylor, J. G.,
Assistant Engineer St. Louis & San Francisco Railroad, Peirce City, Mo.

Thompson, W. S.,
Assistant Engineer Chautauqua Division Pennsylvania Railroad, Oil City, Pa.

Travis, O. J.,
Superintendent of Bridges Illinois Central Railroad, 106 Seventy-sixth Street, Chicago, Ill.

Webster, William R.,
Consulting and Inspecting Engineer, 411 Walnut Street, Philadelphia, Pa.

Woodward, Roland,
Chief Engineer Jacksonville & Southwestern Railroad, Jacksonville, Fla.

LIST OF STANDING COMMITTEES AND OUTLINE OF COMMITTEE WORK.

I.—GRADUATION.

1. Cuttings and embankments:
   (a) Standard cross-sections (variations of same, affected by local conditions).
2. Protection of slopes:
   (a) Sodding; (b) paving; (c) retaining walls; (d) planting willows, etc.; (e) sandbagging; (f) drainage by surface ditches above, below and on slopes, and by tiling.
3. Improvement of grades and alignment:
   (a) Methods used; (b) limit of economy; (c) steam-shovel work.
4. Tunnels:
   (a) Ventilation; (b) maintenance.

J. B. Berry, Chief Engineer Union Pacific Railroad, Omaha, Chairman;
W. McNab, Assistant Engineer Grand Trunk, Montreal, Vice-Chairman;
J. A. Atwood, Chief Engineer Pittsburg & Lake Erie, Pittsburg;
R. C. Barnard, Engineer M.-of-W. Pennsylvania Lines West, Cincinnati;
George M. Brown, Chief Engineer Gulf & Manitoba, Beaver Falls, Mont.;
H. Baldwin, Engineer Maintenance-of-Way Cleveland, Cincinnati, Chicago & St. Louis Railway, Indianapolis, Ind.;
C. Dougherty, Roadmaster Illinois Central Railroad, Chicago;
Committee.

II.—BALLASTING.

1. Material:
   (a) Stone—size, quality; (b) gravel—cementing, loose, sandy; (c) burnt clay—quality, method of burning, etc.; (d) slag, cinder and burnt shale; (e) chatts—character; (f) earth; (g) dust prevention.
2. Standard cross-sections (variations, modified by material and other conditions).
3. Cost:
   (a) Material alone; (b) loading; (c) transportation; (d) unloading; (e) placing under track, surfacing and dressing.
4. Methods:
   (a) Handling material; (b) keeping trace of cost and accounts.
5. What constitutes ballasted track?

W. H. Peddle, Assistant General Manager Southern Railway, Washington, D. C., Chairman;
A. Mordecai, Assistant Chief Engineer Erie Railway, Cleveland, Ohio;
J. R. Leighty, Roadmaster Chicago & Northwestern Railway, Carroll, Ia.;
Edward Shelah, General Roadmaster Wabash Railroad, Decatur, Ill.;
J. T. Richards, Engineer M.-of-W. Pennsylvania Railroad, Philadelphia;
H. U. Wallace, Division Superintendent Illinois Central, Freeport, Ill.;
Committee.

III.—TIES.

1. Material:
   (a) Wood—various kinds; (b) metal—shapes, etc.
2. Preservation:
   (a) Consideration of methods and cost.
3. Inspection:
   (a) When purchasing; (b) when necessary to renew in track.
4. Cost:
   (a) Delivered at side of track; (b) loading; (c) transportation; (d) local distribution; (e) putting in track and spacing.
5. Disposition of old ties:
   (a) Method and cost of utilizing same; (b) use for firewood; (c) use for curbing, retaining walls and otherwise; (d) burning.
6. Methods:
   (a) Handling tie question; (b) reports and accounts.
7. General questions:
   (a) Preparing for track; (b) piling for use; (c) boring for spikes; (d) planing or adzing for tie-plates; (e) lining up on ends; (f) marking for age in service; (g) tie-plates.

J. Kruttschnitt, Fourth Vice-President and General Manager Southern Pacific Company, San Francisco, Cal., Chairman;
G. W. Kittredge, Chief Engineer Cleveland, Cincinnati, Chicago & St. Louis Railway, Cincinnati, Ohio, Vice-Chairman;
J. J. Frey, President Florence & Cripple Creek Railway, Denver, Colo.;

W. L. Darling, Assistant Chief Engineer Northern Pacific Railway, St. Paul;

O. Chanute, Consulting Engineer, Chicago;

William Archer, Principal Assistant Engineer Baltimore & Ohio Southwestern Railroad, Cincinnati, Ohio;

W. C. Cushing, Engineer Maintenance-of-Way Pennsylvania Lines West, Pittsburg, Pa.;

Lewis Kingman, Chief Engineer Mexican Central Railway, Mexico, Mex.;

J. C. Nelson, Division Engineer New York Central & Hudson River Railroad, New York, N. Y.;

Committee.

IV.—RAIL.

1. General specifications:
   (a) Chemical constituents; (b) mechanical manipulation; (c) inspection.
2. Standard sections:
   (a) As to general form, considering differences of section as related to alignment, grades and traffic; (b) as to weight, considering adoption of standard section of weight per yard.
3. Proper length of rails—reasons therefor.
4. Transportation.
5. Local distribution and handling.
6. Laying:
   (a) Methods—single rails or strings; (b) expansion; (c) adzing ties, preparatory to laying.
7. Utilization of relieved rail:
   (a) For patching rail of same kind in main line; (b) for laying on branch lines; (c) passing tracks and sidings; (d) scrap; (e) care and treatment of relieved rail (re-rolling and careful sawing).

Robert Trimble, Principal Assistant Engineer Pennsylvania Lines West, Pittsburg, Chairman;

S. M. Felton, President Chicago & Alton Railway, Chicago, Vice-Chairman;

A. W. Johnston, General Superintendent New York, Chicago & St. Louis Railway, Cleveland, Ohio;

Thomas Purcell, Superintendent Mexican National Railway, Matamoros, Mexico;

W. T. Manning, Consulting Engineer Baltimore & Ohio Railroad, Baltimore;

R. W. Hunt, Consulting Engineer, Chicago;

C. E. Wickham, Division Engineer Chicago, Rock Island & Pacific, Chicago;

J. H. Wallace, Engineer Maintenance-of-Way Southern Pacific Company, San Francisco, Cal.;

G. B. Woodworth, Rail Inspector Chicago, Milwaukee & St. Paul Railway, Chicago;

Wm. R. Webster, Consulting and Inspecting Engineer, Philadelphia, Pa.;

Committee.

V.—TRACK.

1. Maintenance of line:
   (a) Adjustment of tangents; (b) adjustment of curves, with consideration as to easement of curves; (c) methods used in securing and maintaining perfect line.
2. Maintenance of surface:
   (a) Elevation of curves, with special consideration as to amount and beginning and end of elevation, and as modified by location of curve and conditions of traffic; (b) vertical curves; (c) proper methods of tamping.
3. Maintenance of gauge:
   (a) Proper method of spiking; (b) allowance, if any, in gauge of curves, with consideration as to various practices; (c) methods used to prevent spreading of track and canting of rails.
4. Inspection of track:
   (a) Track-walking, consideration as to when resorted to and particular requirement of; (b) special inspection of switches, frogs, crossings, derailing points, interlocking plants, etc., requirements; (c) inspection of bridges, trestles, culverts, etc., by trackmen.
5. Tools:
   (a) Track tools, various kinds; (b) standard equipment for gangs; (c) hand-cars—types and use; (d) push-cars—types and use; (e) dump-cars; (f) methods used in supplying and checking use of.
6. Frogs and switches:
   (a) Types for main line; (b) types for yards; (c) best angle for main line; (d) safety devices in connection therewith.
7. Crossings:
   (a) Foundations and drainage; (b) types of crossings.
8. Guard-rails:
   (a) Spacing of flange-ways; (b) foot-guard protection.
9. Joints and fastenings:
10. General questions:
   (a) Cleaning track; (b) cutting right-of-way, consideration as to time, etc.; (c) care of station grounds; (d) painting, whitewashing, dressing up, etc.

H. F. Baldwin, Chief Engineer Chicago & Alton Ry., Chicago, Chairman;

W. M. Camp, Managing Editor "Railway Review," Chicago, Vice-Chairman;

S. B. Fisher, Chief Engineer Missouri, Kansas & Texas Railway, St. Louis, Mo.;

W. W. Gwathmey, Jr., Chief Engineer Seaboard Air Line, Portsmouth;

A. S. Cheever, Assistant Chief Engineer Fitchburg Division, Boston & Maine Railroad, Boston;

William B. Poland, Division Engineer Baltimore & Ohio Southwestern Railroad, Washington, Ind.;

G. S. Cheyney, Assistant Division Engineer New York Central & Hudson River Railroad, Buffalo, N. Y.;

J. B. Moll, General Roadmaster Chicago, Milwaukee & St. Paul, Chicago;

J. B. Robinson, Resident Engineer Southern Pacific Company, Sacramento;

H. C. Landon, Engineer Maintenance-of-Way Buffalo & Susquehanna Railway, Austin, Pa.;

Committee.

VI.—BUILDINGS.

1. Passenger station buildings:
   (a) Material; (b) standard plans.
2. Freight station buildings:
   (a) Material; (b) standard plans.
3. Combination stations.
4. Machine shops (including engine-erecting, boiler, blacksmith, paint, car-building and repair shop buildings, dry houses, transfer tables, etc.).
5. Round-houses (including turntables, engine pits, drop pits, cinder pits, etc.); manner of handling cinders.
6. Coaling stations:
   (a) Method of handling coal; (b) cost per ton to handle.
7. Sand and oil houses.
8. Coal houses for stations, watch boxes, scale houses, interlocking towers, water stations, icing stations.
9. Water tanks, pump houses and track tanks.
10. Platforms:
    (a) Wooden; (b) cement; (c) brick; (d) stone; (e) cinder.
11. Elevators:
    (a) Transfer; (b) storage; (c) clipping and cleaning.
12. General questions:
    (a) Painting; (b) inspection of; (c) fire protection; (d) Lighting plants and methods; (e) heating methods.

H. W. Parkhurst, Engineer Bridges and Buildings Illinois Central Railroad, Chicago, Chairman;

P. D. Ford, Chief Engineer Long Island Railroad, Richmond Hill, N. Y.:

E. C. Macy, Div. Engineer Iowa Central Railway, Marshalltown, Iowa;

C. E. Bryan, Superintendent Maintenance-of-Way Ohio River Railroad, Parkersburg, W. Va.;

C. Millard, General Manager Chicago, Peoria & St. Louis Ry., Springfield;

M. W. Cooley, Manager National Construction Co., Glens Falls, N. Y.;

B. C. Gowen, Chief Engineer Wisconsin & Michigan, Wausau, Wis.;

A. S. Markley, Superintendent B. & B., Chicago & Eastern Illinois Railroad, Danville, Ill.;

C. T. Norton, Superintendent Mexican International Railway, Porfirio Diaz, Mexico;

H. Pierce, Engineer Maintenance-of-Way Chesapeake & Ohio Railway, Huntington, W. Va.;

I. F. White, Superintendent Track and Structures Cincinnati, Hamilton & Dayton Railway, Hamilton, O.;

G. W. Vaughan, Supervisor of B. & B., New York Central & Hudson River Railroad, New York, N. Y.;

J. D. Isaacs, Assistant Engineer Maintenance-of-Way Southern Pacific Company, San Francisco, Cal.;

F. H. Alfred, Engineer Maintenace-of-Way Wheeling & Lake Erie, Canton, Ohio;

Committee.

VII.—BRIDGES AND TRESTLES.

1. Iron bridges:
   (a) Rolled I-beam spans—consideration as to limit of economical use; (b) plate-girders—consideration as to limit of economy in their use; (c) truss spans—consideration as to various types; (d) draw spans—consideration as to method of operation.
2. Wooden bridges:
   (a) Character and various types; (b) method of protection or care.
3. Trestles:
   (a) Iron—consideration as to comparative cost with wooden trestles; (b) pile—length of spans, character and specifications of piling, protection in salt water, protection at ground line, limit of use, filling; (c) frame bents—construction, bracing, custom in renewal, whether in whole or in part, filling; (d) solid floor trestles.
4. Docks and wharves:
   (a) Coal docks; (b) ore docks; (c) piers and slips; (d) transfer facilities.
5. Miscellaneous:
   (a) Cost per foot—various types; (b) inspection—practice regarding; (c) painting—best method of protection from rust.

Onward Bates, Engineer and Superintendent Bridges and Buildings Chicago, Milwaukee & St. Paul Railway, Chicago, Chairman;
W. A. McGonagle, Resident Engineer and Superintendent Bridges and Buildings Duluth & Iron Range Railroad, Duluth, Vice-Chairman;
A. Ziesing, Consulting Engineer, Chicago;
I. O. Walker, Division Engineer Nashville, Chattanooga & St. Louis Railway, Paducah, Ky.;
E. Barrington, National Railway of Tehuantepec, Coatzacoalcos, Mexico;
R. Modjeski, Consulting Engineer, Chicago;
D. W. Lum, Engineer of Bridges and Buildings, Southern Railway, Washington, D. C.;
B. Douglas, Bridge Engineer Michigan Central Railroad, Detroit, Mich.
William Michel, Engineer Maintenance-of-Way Hocking Valley Railroad, Columbus, Ohio;
T. L. Condron, Civil Engineer, Chicago;

Committee

VIII.—MASONRY.

1. Bridge Masonry:
   (a) Abutments—various forms and economies resulting therefrom; (b) piers, including foundations, coping, etc., also cost of low piers, with use of steel bents, as against full-height piers; (c) bridge seats, mud walls, wing walls, etc.
2. Arch masonry:
   (a) Various types and advantages of same relative to local conditions; (b) practice of use of arches in "T" abutments to save masonry; (c) limit of economy in use as against span bridges.

3. Culvert masonry:
   (a) Forms of; (b) cover-plates, wall-plates, paving; (c) use of rails for cover-plates, with brick or concrete in spaces.
4. Pipe culverts:
   (a) Iron, water and gas pipes, considering foundations used in laying, thickness of pipe, limit of use as to number of lines of pipe and diameter; (b) end walls.
5. Wooden-box drains:
   (a) When permitted.
6. Concrete masonry.

W. L. Breckinridge, Chief Engineer Chicago, Burlington & Quincy Railroad, Chicago, Chairman;
E. P. Dawley, Division Engineer New York, New Haven & Hartford Railroad, Boston, Vice-Chairman;
William Hood, Chief Engineer Southern Pacific, San Francisco, Cal.;
H. G. Kelley, Chief Engineer Minneapolis & St. Louis Railway, Minneapolis;
W. E. Hoyt, Consulting Engineer, Rochester, N. Y.;
F. S. Stevens, Superintendent Philadelphia & Reading Railway, Reading, Pa.;
C. F. W. Felt, Chief Engineer, Gulf, Colorado & Santa Fe Railway, Galveston, Texas;
B. T. Fendall, City Engineer, Baltimore, Md.;
F. M. Bisbee, Superintendent Tracks, Bridges and Buildings St. Louis & San Francisco Railway, Springfield, Mo.;

Committee.

IX.—SIGNS, FENCES, CROSSINGS AND CATTLE-GUARDS.

1. Fences:
   (a) Wire—various kinds; (b) posts used in wire fences; (c) board fences; (d) method regarding maintenance; (e) snow fences.
2. Highway crossings:
   (a) Overhead crossings; (b) under crossings; (c) surface crossings—consideration as to protection of same, planking, approaches; (d) crossing gates—pneumatic, hydraulic, electrical or physical operation.
3. Cattle-guards:
   (a) Surface guards; (b) pit guards; (c) wing fences to cattle-guards.
4. Signs:
   (a) Standard station signs; (b) standard ring whistle posts; (c) standard mile posts; (d) standard highway crossing warnings; (e) standard stop sign boards; (f) standard yard-limit boards; (g) county, city limit and state-line boards; (h) bridge warnings; (i) structure signs—method of indicating.

H. Fernstrom, Chief Engineer St. Joseph & Grand Island, St. Joseph, Chairman;
C. A. Wilson, Chief Engineer Cincinnati, Hamilton & Dayton Railway, Cincinnati, Vice-Chairman;
G. F. Bidwell, General Manager Fremont, Elkhorn & M. V., Omaha;
D. Bontecou, Chief Engineer Kansas City, Ft. Scott & Memphis, Kansas City;
J. R. W. Davis, Engineer Maintenance-of-Way Erie Railroad, Jersey City;
H. J. Slifer, Superintendent Chicago & Northwestern Railway, Boone, Ia.;
W. Shepard, Chief Engineer Boston & Albany, Boston;

Committee.

X.—SIGNALING AND INTERLOCKING.

1. Signals:
   (a) Train-order signals; (b) distance signals; (c) block signals.
2. Interlocking plants:
   (a) Railway crossings protection; (b) switch connections; (c) operating yards.
3. Highway crossing signals:
   (a) Various types; (b) mode of operation.
4. Miscellaneous questions.

H. D. Miles, Signal Engineer Michigan Central Railroad, Detroit, Mich., Chairman;

W. J. Gillingham, Jr., Signal Engineer Illinois Central, Chicago, Vice-Chairman;

J. S. Hobson, Signal Engineer Atchison, Topeka & Santa Fe Railway, Topeka, Kansas;

A. H. Sanford, Engineer Maintenance-of-Way Pennsylvania Lines West, Toledo;

Committee.

XI.—RECORDS, REPORTS AND ACCOUNTS.

1. Reports:
   (a) Labor reports, including method of reporting time worked, with classification of items, with a view of reaching uniformity in this regard; (b) material reports—various forms used in reporting material used to enable complete check to be had on all material used; (c) miscellaneous reports, such as accident, fire claims, stock killed, flood damage, etc.
2. Records:
   (a) Right-of-way records, deed records; (b) station plats; (c) profiles of road; (d) alignment maps; (e) lease records.
3. Accounts:
   (a) Labor accounts; consideration as to classification of distribution to various items of labor; (b) material accounts; consideration as to method of charging out to various classes of work, whether individual accounts with each structure or general accounts; (c) bills against other lines.

H. F. White, Chief Engineer Burlington, Cedar Rapids & Northern Railway, Cedar Rapids, Iowa, Chairman;

Joseph Morrison, Resident Engineer Central Vermont, St. Albans, Vt., Vice-Chairman;

L. F. Goodale, Chief Engineer Burlington's Missouri Lines, St. Joseph, Mo.;

T. J. Frazier, Assistant Superintendent Maintenance-of-Way Baltimore & Ohio Railroad, Zanesville, Ohio;

D. McPherson, Division Engineer Canadian Pacific, Montreal, Can.;

Henry Rohwer, Assistant Engineer Missouri Pacific, Sedalia, Mo.;

George Houliston, Assistant Engineer Pennsylvania Railroad, Buffalo, N. Y.;

Committee.

XII.—UNIFORM RULES, ORGANIZATION, ETC.

1. Proper organization of the Maintenance-of-Way Department.
2. Code of titles, applicable uniformly over the entire country.
3. Rules and Regulations governing employes in the Maintenance-of-Way Department.
4. Code of Maintenance-of-Way Ethics.

D. D. Carothers, Engineer Maintenance-of-Way Baltimore & Ohio Southwestern Railroad, Cincinnati, Chairman;
W. J. Wilgus, Chief Engineer New York Central & Hudson River Railroad, New York, Vice-Chairman;
E. H. Fitzhugh, General Manager Central Vermont, St. Albans, Vt.;
G. A. Quinlan, Vice-President and General Manager Houston & Texas Central Railroad, Houston, Texas;
James Oborne, General Superintendent Canadian Pacific, Winnipeg, Man.;
T. F. Whittelsey, General Superintendent Toledo & Ohio Central Railroad, Toledo, Ohio;
C. S. Churchill, Engineer Maintenance-of-Way Norfolk & Western Railway, Roanoke, Va.;
J. T. Mahl, Engineer Maintenance-of-Way Southern Pacific Company, Houston, Texas;
F. B. Harriman, Superintendent Illinois Central, Dubuque, Iowa;

Committee.

XIII.—WATER SERVICE.

1. Source of supply:
    (a) Surface—method of impounding; (b) subterranean—driven, drilled or open wells.
2. Method of pumping and supply:
    (a) Direct from tanks; (b) through standpipes; (c) through track tanks; (d) cost of pumping; (e) city waterworks supplies; (f) pumping machinery, boilers, etc.
3. Character of water, giving analyses of good and bad water for engines, also use of compounds to counteract impurities.

W. E. Dauchy, Chief Engineer Chicago, Rock Island & Pacific Railway, Chicago, Chairman;
D. Willard, Assistant General Manager Baltimore & Ohio Railroad, Baltimore, Vice-Chairman;
H. C. Draper, Assistant Engineer Chicago & Alton Railroad, Chicago;
O. D. Richards, Chief Engineer Ann Arbor Railroad, Toledo, Ohio;
W. B. Storey, Jr., Chief Engineer Atchison, Topeka & Santa Fe Railway, Topeka, Kan.;
G. H. Webster, Resident Engineer Canadian Pacific Railway, Winnipeg, Man.;
Samuel Rockwell, Principal Assistant Engineer Lake Shore & Michigan Southern Railroad, Cleveland, Ohio;

Committee.

XIV.—YARDS AND TERMINALS.

1. Freight terminal yards.
2. Passenger terminal yards.
3. Passing sidings:
   (a) Best form of; (b) economical length; (c) location for passing track on double track.
4. Station tracks:
   (a) Best forms, consideration as to convenience for teaming tracks, etc.; (b) industrial tracks.
5. Gravity and poling yards.
6. Train sheds:
   (a) Pocket sheds; (b) through sheds; (c) arrangement of tracks, etc.
7. "Y" tracks.

A. W. Sullivan, General Superintendent Illinois Central Railroad, Chicago, Chairman;
F. E. Paradis, Chief Engineer Chicago Terminal Transfer Railroad, Chicago, Vice-Chairman;
J. W. Thomas, Jr., General Manager Nashville, Chattanooga & St. Louis Railway, Nashville, Tenn.;
I. G. Rawn, General Superintendent Baltimore & Ohio Southwestern Railroad, Cincinnati;
E. E. R. Tratman, Resident Editor Engineering News, Chicago;
R. B. Tweedy, Chief Engineer Wisconsin Central, Milwaukee, Wis.;
S. P. Hutchinson, Assistant General Agent Pennsylvania Railroad, New York;
J. B. Cox, Chief Engineer Chicago Junction Railway, Chicago;
C. W. Hotchkiss, Consulting Engineer, Chicago;
C. S. Sims, Jr., Engineer Maintenance-of-Way Pennsylvania Lines West, Chicago;
W. S. Kinnear, Principal Assistant Engineer Michigan Central Railroad, Detroit. Mich.;

Committee.

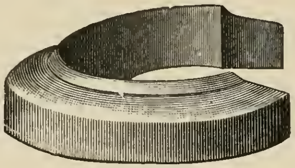
STATEMENT SHOWING THE MILEAGE OF THE ROADS REPRESENTED BY MEMBERS OF THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION.

Name of Road.	Mileage.	No. of Members.
Algoma Central Railway	120	1
Ann Arbor Railroad	292	1
Arizona and Utah Railway	26	1
Arkansas Northern Railway	125	1
Atchison, Topeka & Santa Fe Railway	7,426	4
Baltimore & Ohio Railroad	2,047	5
Baltimore & Ohio Southwestern Railroad	921	5
Bismarck, Washburn & Great Falls Railroad	48	1
Boise, Nampa & Owyhee Railway	50	1
Boston & Albany Railroad	394	1
Boston & Maine Railroad	3,260	3
Buffalo and Susquehanna Railroad	162	2
Buffalo. Rochester & Pittsburg Railway	472	1
Burlington, Cedar Rapids & Northern Railway	1,171	2
Burlington's Missouri Lines	1,067	3
Canada Atlantic Railway	464	1
Canadian Pacific Railway	7,982	7
Central New England Railway	181	1
Central of Georgia Railway	1,560	1
Central Vermont Railway	511	2
Chesapeake & Ohio Railway	1,476	2
Chicago & Alton Railway	907	6
Chicago & Eastern Illinois Railroad	711	3
Chicago & Northwestern Railway	8,258	5
Chicago & Western Indiana Railway	55	1
Chicago, Burlington & Quincy Railroad	6,412	1
Chicago Junction Railway	385	1
Chicago, Milwaukee & St. Paul Railway	6,423	5
Chicago, Peoria & St. Louis Railway	292	1
Chicago, Rock Island & Pacific Railway	3,647	2
Chicago Terminal Transfer Railroad	262	4
Choctaw, Oklahoma & Gulf Railroad	627	1
Cincinnati, Hamilton & Dayton Railway	652	2
Cincinnati Northern Railroad	402	2
Cleveland, Akron & Columbus Railway	219	1
Cleveland, Cincinnati, Chicago & St. Louis Railway	2,287	5
Cleveland, Lorain & Wheeling Railway	196	1

Name of Road.	Mileage.	No. of Members.
Colorado & Southern Railroad	1,141	1
Columbia & Southern Railway	70	1
Delaware, Lackawanna & Western Railroad	947	1
Denver & Rio Grande Railroad	1,674	2
Duluth & Iron Range Railroad	161	1
Erie Railroad	2,272	2
Esquimalt & Nanaimo Railway	80	1
Evansville & Terre Haute Railroad	317	1
Federal District Railway of Mexico	220	1
Florence & Cripple Creek Railroad	60	1
Fort Worth & Denver City Railroad	452	1
Fremont, Elkhorn & Missouri Valley Railroad	1,301	1
Fulton County Railroad	61	1
Grand Trunk Railway	4,179	5
Great Northern Railway	6,417	1
Gulf & Ship Island Railway	250	2
Gulf & Manitoba Railroad	167	1
Gulf, Colorado & Santa Fe Railway	1,128	3
Halifax & Yarmouth Railway	51	1
Hocking Valley Railway	346	1
Houston & Texas Central Railroad	625	2
Houston East & West Texas Railway	192	1
Illinois Central Railroad	4,246	34
Illinois Southern Railroad	100	1
Iowa Central Railway	546	1
Jacksonville & Southwestern Railroad	71	1
Kansas City, Fort Scott & Memphis Railroad	1,243	2
Kansas City, Mexico & Orient Railway	365	1
Lake Erie & Detroit River Railway	182	1
Lake Shore & Michigan Southern Railway	1,413	3
Lehigh Valley Railroad	1,404	3
Long Island Railroad	393	2
Louisville & Nashville Railroad	3 235	2
Mexican Central Railway	2.265	1
Mexican International Railway	827	1
Mexican National Construction Company	89	1
Mexican National Railroad	1,331	1
Michigan Central Railroad	1,658	5
Minneapolis & St. Louis Railroad	642	1
Minneapolis, St. Paul & Sault Ste. Marie Railway	1,278	1
Missouri, Kansas & Texas Railway	2.424	1
Missouri-Pacific Railway	5,352	1
Mobile & Ohio Railroad	876	2
Montana Railroad	100	1
Nashville, Chattanooga & St. Louis Railway	1.189	4
National Docks Railway	23	1

Name of Road.	Mileage.	No. of Members.
National Railway of Tehuantepec	228	1
Nevada County Narrow Gauge Railroad	23	1
New York Central & Hudson River Railroad	6,295	6
New York, Chicago & St. Louis Railroad	513	2
New York, New Haven & Hartford Railroad	2,038	2
New York, Philadelphia & Norfolk Railroad	112	1
Norfolk & Southern Railroad	144	1
Norfolk & Western Railway	1,555	1
Northern Pacific Railway	5,487	2
Ocos Railway	30	1
Ohio River Railroad	267	2
Pacific Coast Company	210	1
Pennsylvania Lines West of Pittsburg	4,390	10
Pennsylvania Railroad	4,847	7
Peoria & Eastern Railway	352	2
Pere Marquette Railroad	1,735	1
Philadelphia & Reading Railway	1,457	4
Pittsburg & Lake Erie Railroad	180	4
Pittsburg & Western Railway	354	1
Pittsburg, Connellsville & Western Railway	100	1
St. Joseph & Grand Island and K. C. & O. Railways	514	1
St. Louis & San Francisco Railway	1,659	2
San Francisco & San Joaquin Valley Railway	375	1
Santa Fe, Prescott & Phœnix Railway	197	2
Seaboard Air Line	2,586	2
South Haven & Eastern Railroad	37	1
Southern Pacific Company	7,413	21
Southern Railway	6,431	8
Tennessee Central Railway	65	1
Terminal Railroad Association of St. Louis	18	1
Terre Haute & Indianapolis Railroad	448	1
Terre Haute & Logansport Railway	182	1
Toledo & Ohio Central Railway	525	2
Toledo, St. Louis & Western Railway	451	1
Union Pacific Railroad	3,031	2
Vera Cruz & Pacific Railroad	85	1
Union Stock Yards & Railroad Company of Omaha	50	1
Wabash Railroad	2,358	2
Waycross Air Line	48	1
Wheeling & Lake Erie Railroad	464	1
Wisconsin & Michigan Railroad	72	1
Wisconsin Central Lines	950	2
Yazoo & Mississippi Valley Railroad	1,013	3
Miscellaneous	.....	29
Total	174,456	330

190,000,000



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HAVE BEEN USED IN RAILROAD TRACK ALONE

The National Lock Washer Company
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TRACK EQUIPMENT

"Strom" Clamp Frogs
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The Best and Cheapest Wood Preserver to Be Had

Highest Awards at World's Fair, Chicago, 1893,
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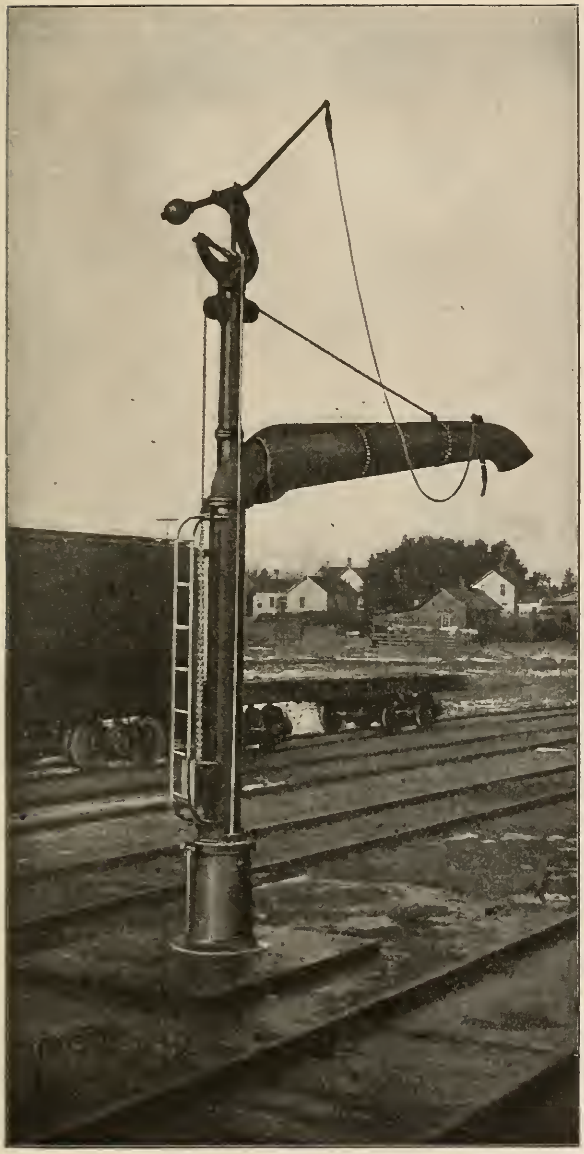
WILMINGTON, N. C.

THE WOOD PRESERVER manufactured by the Spirittine Chemical Co. of Wilmington, N. C., has been thoroughly tested and found satisfactory in every respect. In the month of June, 1887, 252 sap pine cross ties were treated with it and were placed in track on the W. & W. R. R. (the main line of the Atlantic Coast Line); and the Roadmasters, in their report to General Manager Kenly, say they are as good as when they were put down, and they can see no reason why they should not last 5 years longer. Prolonging the life of a sap pine tie, which under normal conditions is only 2 years, to 13, with every prospect of extending it to 18 years, at such a small cost, is worthy the consideration of all who are interested in the preservation of wood. It not only preserves but makes the wood much less inflammable. In a test made at our factory in the presence of Capt. Manning, a government official from Washington City, and our General Manager, the treated wood ignited in 12 minutes, while the untreated piece from the same wood took fire in 30 seconds. Its analysis meets the most exacting requirements, being as follows:

Flashing Point,	214°
Burning Point,	235°
Specific Gravity,	1.05

Additional information furnished on application



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⁂

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Pumping
Plants

⁂

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Stations
Erected
Complete

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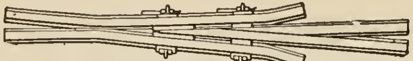
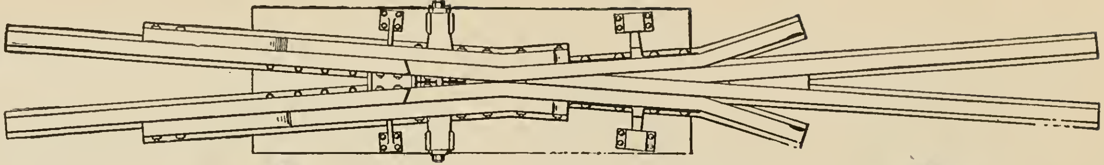
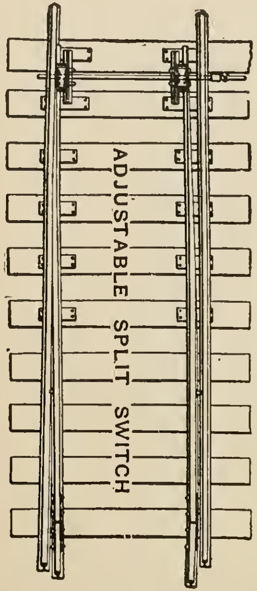
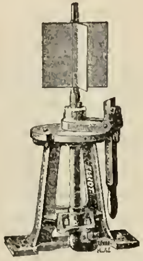


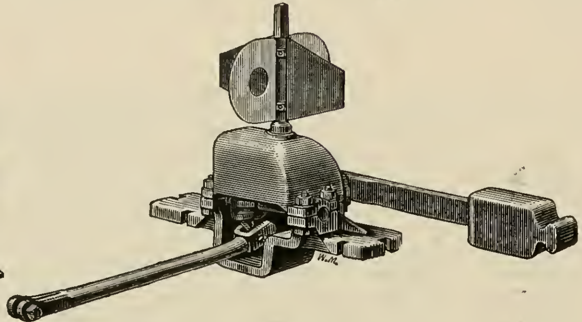
STEEL CLAMP FROG





ADJUSTABLE SPLIT SWITCH





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EAST ST. LOUIS, - - ILLINOIS
Manufacturers of
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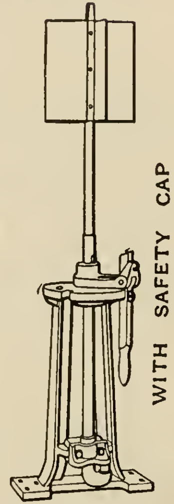
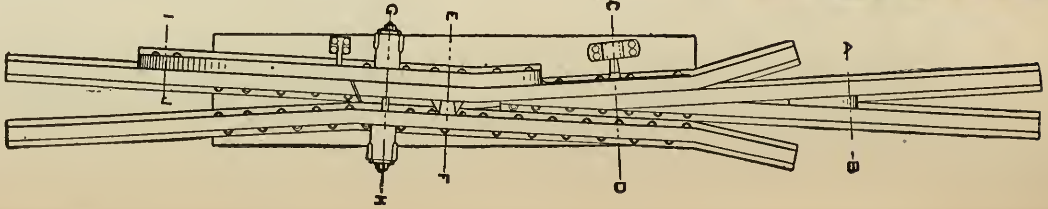


HIGH MAIN LINE STAND
WITH SAFETY CAP

BOLTED FROG



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(*Hasselmann System*)

This is the only method of wood impregnation that Insures

Thorough and Even Penetration Even to the Innermost Core.

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Insolubility of the Preservative Agents, so They Are Not Washed Out by Action of Rain or Water.

❧

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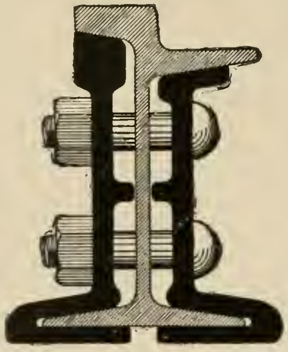

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Fewest Parts
Strongest and Safest
Best Economical Results
Provides for the Increased
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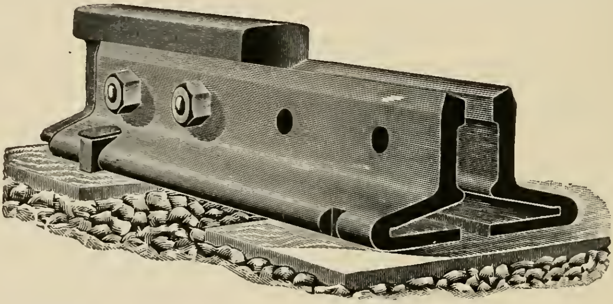

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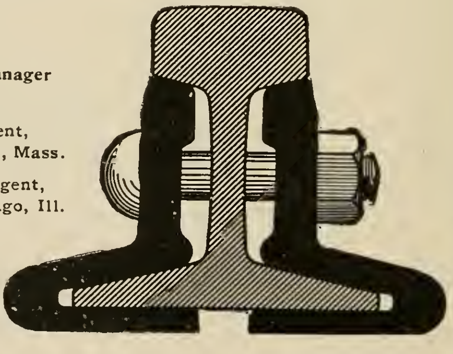

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HARVEY, ILLINOIS

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Over 1 250 000 in use

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The American Washer and Manufacturing Co.

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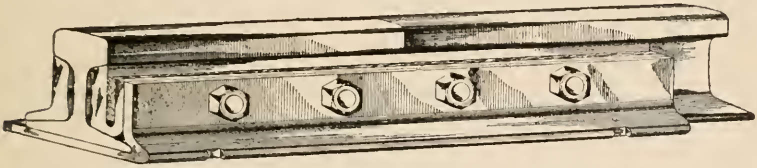

THIS joint possesses scientific principles which should strongly appeal to all Engineers and Maintenance Men. In this joint we have the angle bar fit; the bolts will adjust all bearings; the small wood filler will make the joint noiseless; the resilience in the two upright members provides powerful compensating force which will preserve tension on the bolts, so that the sole-plate which clamps a portion of the rail-base cannot drop down, and at the same time these uprights act as girders against direct stress of wheel-blows and will also resist lateral thrusts. The wood is specially treated.

Wood Preserving

CREO=RESINATE PROCESS
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The Creo=Resinate Process Consists of:

First—Vulcanizing—this being a drying and a perfect sterilizing process.

Second—Application of creo-resinate process—this being a second treatment of creosote, resin and formaldehyde, under 200 lbs. pressure, producing an insoluble, waterproof, antiseptic compound, filling the pores of the wood.

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We are, at the same time, prepared to treat timber, using the ordinary creosoting (dead oil of coal tar) process.

We have the largest plant in the world for the treatment of wood, having a capacity of fifty million feet per year.

We cordially invite engineers to visit our works and have the plant run under their direction while there, to thoroughly investigate our process.

UNITED STATES WOOD PRESERVING CO.

71 Broadway, New York.

CHICAGO BRIDGE AND IRON CO.

HORACE E. HORTON, Proprietor

CHICAGO, = = ILLINOIS

DESIGN, MANUFACTURE AND BUILD

STRUCTURAL STEEL, AS
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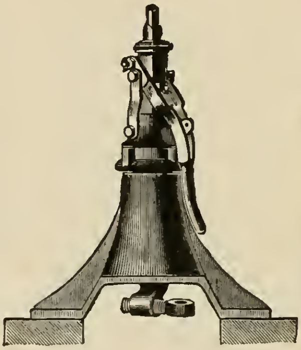

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Modern
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Equipment

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14 Years' Experience

Works at Chicago, Ill., and Mt. Vernon, Ill.

Is Prepared to Erect Works and to
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MEASURING TAPES

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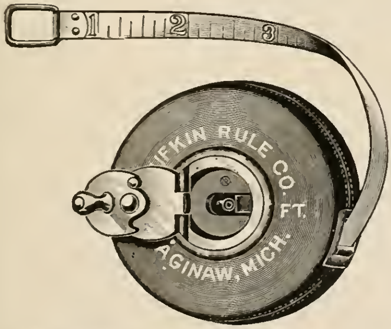

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LUFKIN TAPE
AND YOUR WORK
WILL BE WELL
DONE

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PAGE

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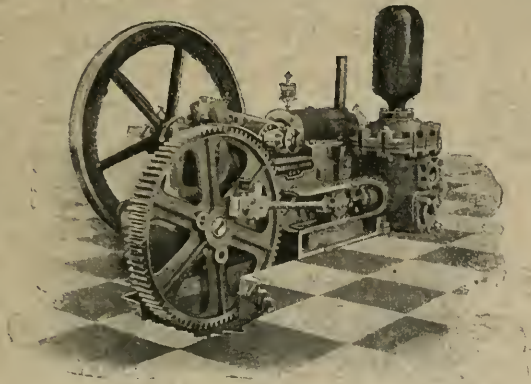

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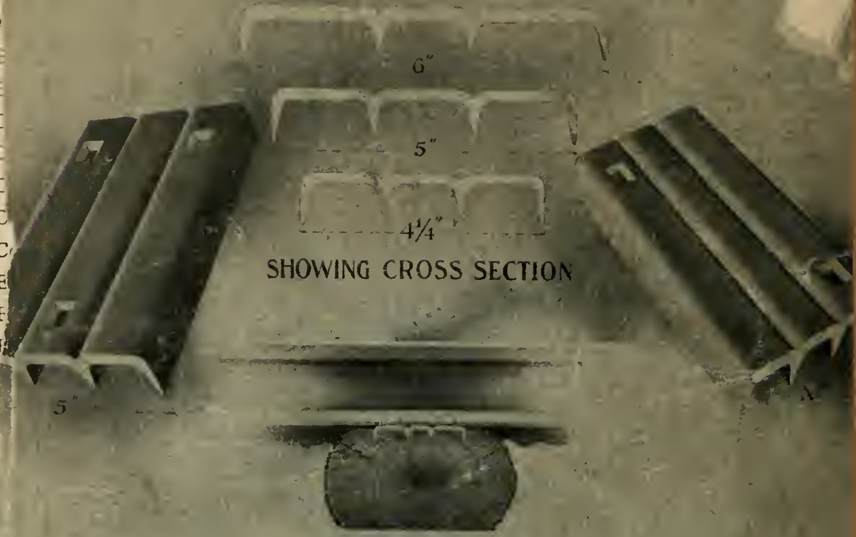
Q and W TIE PLATE



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